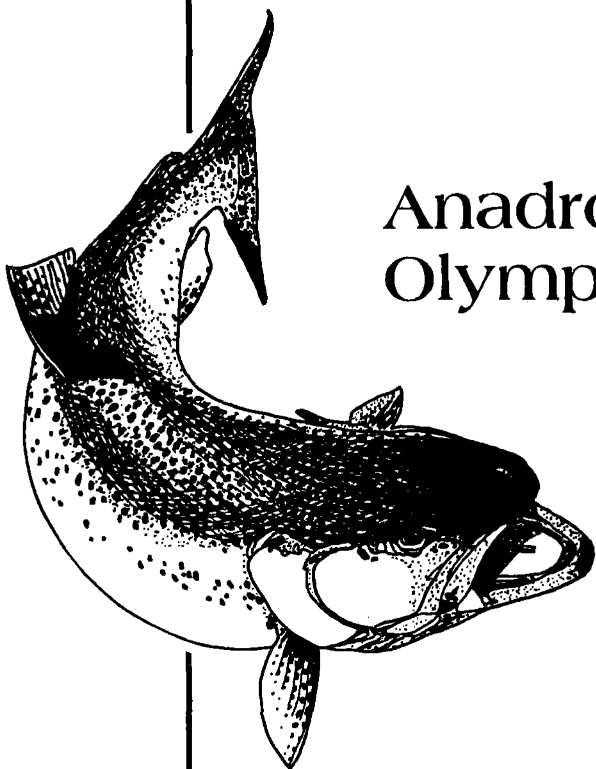

Anadromous Fish in Olympic National Park: A Status Report

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CONTENTS

ANADROMOUS FISH IN OLYMPIC NATIONAL PARK: A STATUS REPORT

INTRODUCTION

Olympic National Park is the only natural area administered by the National Park Service outside Alaska to have substantial numbers of native anadromous salmonids as part of the park fauna*. This report presents a preliminary review of the distribution and abundance of the salmonid (salmon and trout) populations of particular importance to the park. Most of these populations are harvested in commercial and sports fisheries outside park boundaries, at sea and on the lower reaches of the rivers. In addition, recreational fishing is permitted in park waters. Consequently, this segment of the park's fauna is subject to management by other federal and state agencies and by several Indian tribes. The management objectives of these other agencies are reviewed briefly. The nature and extent of the conflicts with the park's primary purpose of preserving and restoring natural ecological processes are discussed, and management strategies are considered.

*Small numbers of anadromous salmonids occur in parts of North Cascades, Mt. Rainier, and Redwoods National Parks and in Muir Woods National Monument.

STUDY AREA AND METHODS

Olympic National Park was established in 1938 and presently consists of two separate units totaling 1420 mi^2 (Fig. 1). A narrow coastal strip of 50 mi^2 extends for about 52 mi from the Makah Indian reservation south to the Quinault reservation. Although completely surrounded by the park, the waters of the 7,300 acre Lake Ozette are not under National Park Service (NPS) jurisdiction. The remaining 1,370 mi^2 unit of the park includes the rugged Olympic Mountain Range and the headwaters of many of the large rivers on the Olympic Peninsula.

This report is concerned mainly with those drainages in the western one-half of Olympic National Park -- the Ozette, Quillayute (including Dickey, Soleduck, Bogachiel and Calawah), Hoh, Queets and Quinault Rivers. A review of the Washington Department of Fisheries Stream Catalogues (1975 Vol. I & II) and discussions with Department personnel show that all remaining park rivers have either natural or man-made barriers to anadromous fish below the park's boundary, with the exception of about one mile on the upper Gray Wolf River (Appendix Table I). Dams eliminated anadromous fish from the entire Elwha drainage within the park as well as a small area used historically on the North Fork Skokomish River. The loss of anadromous fish from the Elwha represents a major change in the fauna of one of the most important park rivers.

Lands between the two units of Olympic National Park (ONP) are owned and managed primarily by Olympic National Forest, Washington Department of Natural Resources, and various private timber companies. Five Indian rservations also border park lands on the west; these range in size from the Hoh reservation of less than 1 mi^2 to the Quinault reservation of nearly 300 mi^2 (Fig. 1). The north

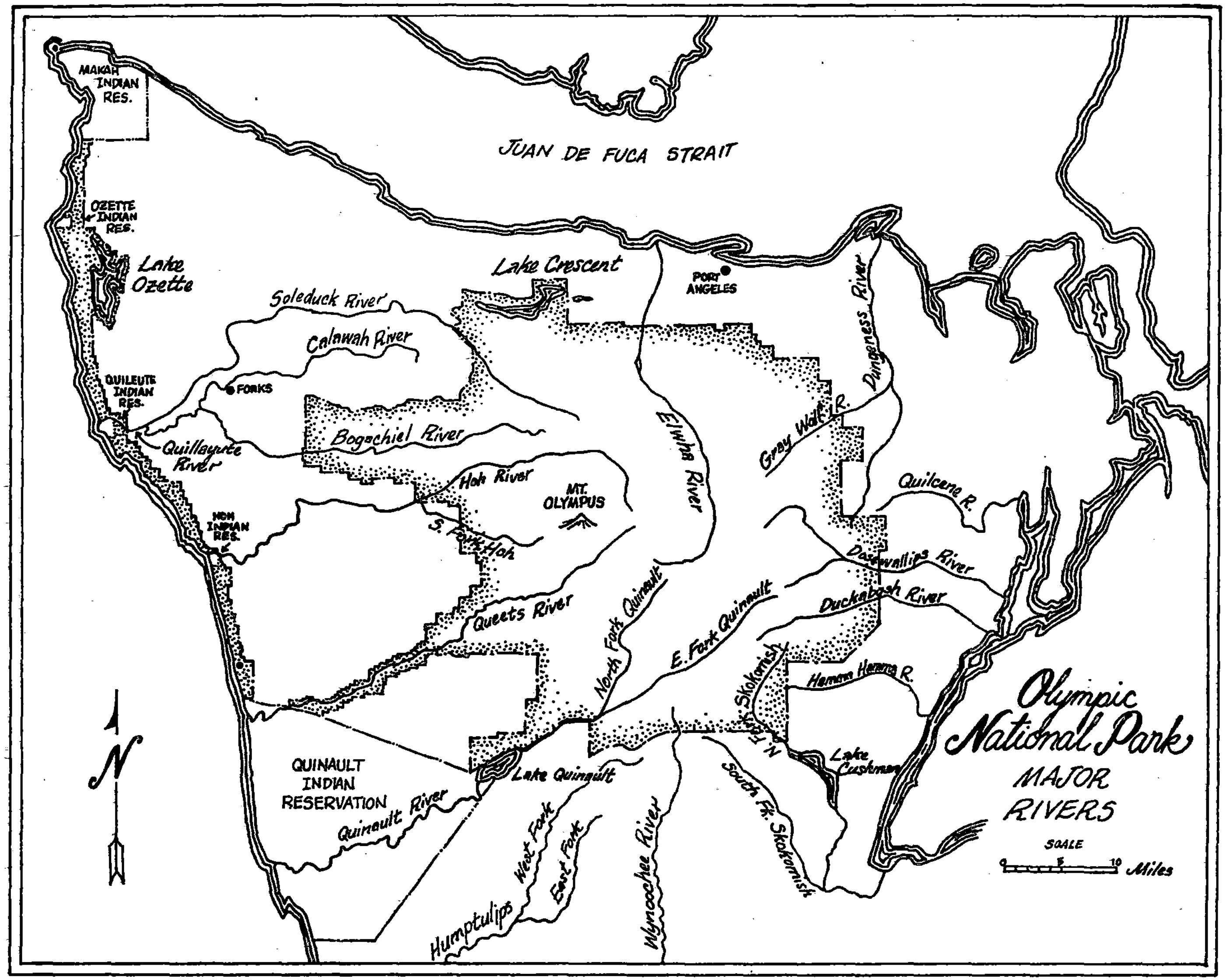

Fig. 1. Olympic National Park showing major rivers.

shore of the 3,700 acre Lake Quinault forms the park boundary; lake waters are under the jurisdiction of the Quinault tribe. Fishing continues to play an important role in the culture and economy of all tribes.

Geology of the western part of ONP has been summarized by Tabor (1975). Vegetation over most of the area is coniferous forest dominated by massive western hemlock (*Tsuga heterophylla*), red cedar (*Thuja plicata*), Sitka spruce (*Picea sitchensis*), and Douglas-fir (*Pseudotsuga menziesii*) (Franklin and Dyrness 1973, Fonda 1974). The park forests and the rivers that flow through them are viewed here as being in essentially a pristine state. Exceptions include cleared areas around abandoned homesteads and existing private lands and park developments. Much of the forest in the coastal strip was cut before being added to the park, and abandoned homesteads occur around Lake Ozette. Forests outside the park have been logged extensively.

The study area receives the heaviest precipitation in the conterminous United States (NOAA 1978). Annual precipitation ranges from 70-100 inches on the coastal strip to over 200 inches near the crest of the Olympic range (Phillips and Donaldson 1972). Winter precipitation falls mostly as rain along the coastal strip and lowland forests below 1,000 feet. Snowfall may exceed 500 inches near the crest of the Olympics.

The combination of moderate temperatures, steep slopes, short drainages, and great annual precipitation means that rivers of the western Olympics are characterized by very rapid rises and falls in discharge ("flashy runoff") and frequent high flows (Wagner 1983 per. com.). The Hoh is regarded as the most dynamic coastal river. It is fed by glacial melt water and, consequently, carries the highest load of inorganic sediment. The drainage area, length, and

water discharge characteristics for six park rivers are shown in Table 1. Rivers are mostly 50-70 miles in length and drain areas of 300-600 mi^2. Average annual discharge for the Hoh, Queets and Quinault rivers range from about 2-3 million acre feet. Annual runoff of this volume would cover the drainages to depths of 100-150 inches if distributed uniformly. Annual discharge for the Elwha is considerably smaller. Average daily discharges range from 1,000-4,000 ft^3/sec. Even though records are available for only a comparatively short time, the recorded maximum daily discharge of 130,400 ft^3/sec. for the Queets is 32 times greater than the mean flow. A preliminary analysis of annual momentary maximum flows on the Quinault River during November-April periods of 1911-78 showed that unusually large floods occurred in the late 1940s and 1950s (Gilbertson 1981). Floods apparently coincided with a marked decline in sockeye salmon (Oncorhynchus nerka) production which persists to the present. A detailed study of the frequency and magnitude of peak and low flow characteristics of the coastal rivers would be particularly useful because these unpredictable natural "disasters" (in the sense of Harper 1977: 627) influence salmonid production and survival and limit the management precision possible.

The information on anadromous fish contained herein was taken mostly from unpublished reports and records of the Fisheries Departments of the Makah, Quileute, Hoh and Quinault tribes, the Washington Departments of Fisheries (WDF) and Game (WDG), and the U.S. Fish and Wildlife Service. Biologists from these same agencies provided their most recent information on fish distribution, abundance and harvest. Many weights and measurements in use locally are still made in English units (rivermiles, ft^3/sec., pounds) -- these are retained throughout the report.

TABLE 1. DRAINAGE SIZE AND WATER DISCHARGE RECORDS FOR SELECTED RIVERS OF OLYMPIC NATIONAL PARK[a/]

River	Drainage Size[b] Area	Drainage Size[b] River Miles	Station Location[c]	Period of Record	DISCHARGE Average Annual (Acre ft/yr x 10^6)	DISCHARGE in/yr[d]	Daily (ft^3/sec) Min.	Daily (ft^3/sec) Mean	Daily (ft^3/sec) Max.
Ozette	88 (19)	13	L. Ozette (outlet)	1976-79	Station discontinued 9/79.		20		1,500
Quillayute	629 (30)	70[f]	RM 0.7	1978-79	Station in tidal effect at all stages.				
Soleduck	226 (32)	54	RM 13.9	1977-79			155		20,800
Bogachiel	287 (29)	47	RM 15.3	1975-79			85		18,600
Calawah	133 (20)	31	RM 6.6	1899-1901, 1977-79	0.74	107	15	1,018	22,600
Hoh	299 (60)	56	RM 15.4	1960-79	1.82	134	396	2,505	46,000
Queets	449 (34)	51	RM 4.6	1931-49, 1975-79	2.99	126	368	4,126	130,400
Quinault	434 (47)	69	L. Quinault (outlet)	1911-79	2.05	146	276	2,830	50,200
Elwha	321 (85)	45	RM 8.6	1897-1901, 1918-79	1.09	75	10[e]	1,504	41,600

a. Mostly from water resources data for Washington, USGS Survey water data report WA-79-1.1979, and WDF 1975.

b. Area as mi^2 and (% area within Olympic Park). River miles represent distance from Ocean to Headwaters. About 17 mi^2 of Ozette watershed estimated to occur in park.

c. RM = River mile.

d. Depth to which drainage area would be covered if all runoff uniformly distributed.

e. Flows partly regulated by dam at Lake Mills.

f. Quileute continues as Soleduck River, See Fig. 1.

THE ANADROMOUS FISH

Life Histories. General life histories for seven species of native wild salmonids in the coastal rivers are shown in Table 2. The quantity and quality of information varies considerably among species and populations. Aspects of the life history of summer coho (*O. kisutch*), sea run cutthroat (*Salmo clarki*) and summer steelhead (*Salmo gairdneri*) are poorly known. The data on mean weights and ages at return are generally from samples taken in tribal net fisheries, and, as such, may be biased by gear selection and sampling period. In several cases, e.g., summer coho, chum (*O. keta*), the weights include both hatchery and wild fish.

The information in Table 2 greatly oversimplifies the variation in life history themes. Differences in life histories occur within the populations of a single species on the same river, and among rivers. Thus, steelhead reportedly enter the Queets River during virtually every week of the year (Quinault Fisheries Division 1982a); their division here into summer and winter forms must obscure considerable variation in life habits. Similarly, it is unclear if the small numbers of sockeye reported in the Hoh and Queets are dispersing strays from the Quinault River or if they represent true, sustained river dwelling forms. Additional information on life histories can be found in the annual reports of the Quinault Fisheries Division (QFiD), the Hoh Tribal Fisheries (HTF), and in Royal (1972) and Chapman (1979). Studies of the life histories of major populations utilizing park waters are in progress (Reisenbichler 1982).

Several populations show unusual life history features. The Quillayute summer coho, characterized by August and early September river entry and October-mid November spawning less than 65 miles from the sea, is apparently very unusual

TABLE 2. GENERAL LIFE HISTORY OF 7 SPECIES OF WILD ANADROMOUS SALMONIDS IN OLYMPIC NATIONAL PARK [a]

STOCK	EMERGENCE FROM GRAVEL	FRESH WATER RESIDENCE	DOWNSTREAM MIGRATION	SALTWATER RESIDENCE	RIVER ENTRY ADULTS	SPAWNING	AGES AT RETURN	MEAN WT. AT RETURN (lb)	COMMENTS AND SOURCE
Coho, F	Feb.-Apr.(?)	1	May-June	~2	Mid Oct.-Nov.	Nov.-Dec.	3	10	Info mostly for Hoh stock. HTF 1976. Chapman 1979.
Coho, SU	?	1	?	~2	Aug.-early Sept.	Oct.-mid Nov.	3	9	Quillayute R. only. Wood 1982 per. com. QFD 1982.
Chinook, SP SU	Feb.-March	5-8 mo.	July-Oct. Ocean entry	3-5	Mar.-Aug.	Late Aug.-mid Oct.	4-5	21	Queets & Hoh stocks. Very few juveniles migrate to sea as yearlings. QFiD 1981b.
Chinook, F	Feb.-Apr.	5-8 mo.	July-Oct. Ocean entry	3-5	Mid Sept.-Nov.	Mid Oct.-early Dec.	3-5	22	QFiD 1981a.
Sockeye	Mar.-May	1-3	Mar.-June	1-4	Mostly May-June	Nov.-Jan.	4-5	4	Quinault stock. Adults return from Dec. through August. QFiD 1981b.
Pink	Mar.-May	Move to salt-water soon after emergence		2	Aug.-Sept.	Aug.-Oct.	2	6	General life cycle. WDF 1975.
Chum	Feb.-May	Move to salt-water after emergence		3-4	Oct.-Dec.	Oct.-Dec.	3-4	12	Mostly for Hoh stocks. HTF 1976.
Steelhead, W	June-July	2	Apr.-June	2-3	Nov.-Apr.	Mar.-June	4-5	10	Queets & Hoh stocks. HTF 1976, 1979. QFiD 1981a,c.
Steelhead, SU	?	?	?	?	May-July	?	?	?	Hoh mostly. Believed to spawn earlier and higher up drainages. Royal 1972. Chapman 1979, HTF 1976, 1979.
Cutthroat	May-June	2-3	May-July	Variable	Variable	Jan.-Mar.	4-5	--	June 1981. Bogachiel River. Fuss 1978. Royal 1972.

a. For "adults" only; excludes precocious males. Time in years unless otherwise indicated.

(Reisenbichler 1982 per. com.). Quinault sockeye show an unusually long, nine month, period of river entry. Although 80-90% of the adults return in May and June, some return from December through August. Adults reside in Lake Quinault for 3-10 months before spawning. The Quinault sockeye are considered to be composed of many different "substocks" (QFiD 1981b). Season of return for adult salmonids is thought to be under strong genetic control (Ricker 1972).

Pink salmon (O. gorbuscha) are uncommon in coastal rivers. Life history information for this species was taken from general accounts for other areas of Washington. Apparently, the small populations of pink salmon on the coast spawn mainly during even-numbered years, in marked contrast to the odd-numbered year returns common elsewhere in the state (Wright 1983, per. com.). It is worth noting that the Dungeness River supports two groups of pink salmon, including an unusual early run that spawns in the upper river. Peak river entry for the early population occurs in late July, and spawning occurs during late August and early September (WDF 1975). These fish are of limited interest to the NPS since only about one mile of the upper Gray Wolf River in Olympic Park is used as part of a much larger spawning area.

The coastal rivers are known to support species of anadromous fish other than those of major concern here. These include: Dolly Varden (Salvelinus malma), eulachon (Thaleichthys pacificus), green sturgeon (Acipenser medirostris), white sturgeon (A. transmontanus), pacific lamprey (Entosphenus tridentata) and perhaps long fin smelt (Spirinchus thaleichthys) and river lamprey (Lampetra ayresi). In addition, there may be marine forms of three-spine stickleback (Gasterosteus aculeatus) that enter freshwater to spawn and die. Life history information for these species in Washington is summarized by Wydoski and Whitney (1979).

ABUNDANCE AND DISTRIBUTION

Stock Status. Brief reviews of the terminology of fisheries management and the nature of the fisheries that crop the anadromous fish of Olympic Park are a necessary introduction to discussions of the status of these populations.

A salmonid stock is considered to be a population of fish that is reproductively isolated in space or time from others of the same species and tends to be genetically distinct (Larkin 1972, Ricker 1972, Ihssen et al. 1981, California Gene Resource Program 1982). There may be groups within a stock which are semi-discrete and that do not participate fully in a common gene pool. These are termed "substocks" (Larkin 1972). A native wild stock means a naturally spawning stock indigenous to an area. Hatchery stocks may be derived from native or introduced stocks. To muddy this distinction, there is at least one established case in the coastal rivers, Quinault fall chinook (*O. tshawytscha*), where a largely introduced hatchery stock reproduces successfully in the wild. These "early wild" fish are separated from a "late wild" (indigenous) stock by migration time and age composition (Gilbertson 1982 per. com.). Such fish are still considered here to be introduced or exotic. A run may consist of a number of stocks grouped together on the basis of similarity of migration times (Ricker 1972). Thus the Queets coho run is composed of a wild native stock and an introduced hatchery stock.

For pragmatic harvest management, stocks of wild fish in the coastal rivers are defined by time of river entry for each major river; i.e., Hoh fall chinook, Queets winter steelhead, Ozette sockeye. As mentioned above for Quinault sockeye and Queets steelhead, these definitions likely underestimate stock diversity. Additionally, it's unclear how discrete biologically the spring

chinook (adults enter Hoh from April-mid June) are from summer chinook (late July-August entry); all are grouped for management usually as a spring/summer stock. Similarly, fall chinook, fall coho and winter steelhead on the Quillayute system are considered essentially as single stocks rather than recognizing, for example, Soleduck and Bogachiel River stocks (See Fig. 1). Studies in progress should aid stock definition and characterization (Reisenbichler 1982). In the interim, definitions of stocks in use by on-site fisheries managers are followed in this report.

Essentially all anadromous stocks of each of the salmon and trout species of Olympic Park are harvested by man. Cutthroat trout and Dolly Varden are taken in sport fisheries inside and outside the park. Sockeye and chum salmon are taken mainly by Indian net fisheries on the lower rivers. Steelhead are taken mainly by tribal net fisheries on the lower rivers and by sport fishermen. Chinook salmon from Washington coastal rivers are taken at sea in "mixed stock fisheries" by commercial trollers and sport fishermen from Alaska to Washington. Similarly, coho from the Washington coast are taken at sea in mixed stock fisheries from British Columbia to California. Stocks of both species are harvested additionally by Indian net fisheries and sport fisheries as they return to coastal rivers. Tribal net catches of all species are sold commercially and also used for subsistence and ceremonial purposes. Detailed descriptions of these fisheries are given in the annual reports of the Quileute, Hoh, and Quinault Tribal Fisheries Departments. Overall coho and chinook fisheries management policies and problems are discussed by the Pacific Fishery Management Council (1982).

For all stocks the population that survives this formidable array of hooks and nets to spawn is referred to appropriately as the escapement.

Information on estimated numbers of fish returning to the rivers, river catch, and escapement was available for 35 native wild salmonid stocks that occur in and adjacent to Olympic Park (Table 3). Spawning populations of salmon range in size from perhaps a few hundred to over 35,000 fish. These include six recognized coho stocks; five fall stocks with average escapements ranging from 3,000-8,000 fish, and one summer stock of fewer than 1,000. Average escapements for three major fall chinook stocks range from about 1,000-4,000 fish. Ozette fall chinook probably number only a few hundred (WDF 1982c). No escapement estimates are available for native wild Quinault chinook, although commercial harvests exceed 1,000 fish annually. Generally, fall chinook are more numerous than the spring/summer stocks. Four spring/summer stocks range in size from several hundred to 1,000 or more. The five sockeye stocks include three possible river dwelling groups with populations of a few hundred fish (at most), through the Lake Ozette stock with a recent escapement of 2,400, to the Lake Quinault population that exceeds 35,000 -- the largest stock occurring, in part, within park waters. No estimates of escapement are available for the four chum salmon stocks; annual catches average a few hundred fish each, and the Quinault stock is now considered to be essentially a hatchery-based run. Four pink salmon stocks may contain up to 300 fish each.

Spawning populations for four winter steelhead stocks ranged from about 1,500-6,400. Little is known about the size of other steelhead stocks, except that 10 or fewer fish were estimated to be caught annually from 1977-81 by sport fishermen from the Ozette River and Kalaloch Creek (WDG 1979-81). Native wild summer steelhead are much less abundant than winter stocks. No escapement estimates are made, but annual sport plus commercial catches for three stocks

TABLE 3. ESTIMATED RUN SIZE CATCH AND ESCAPEMENT FOR 35 WILD SALMONID STOCKS IN OLYMPIC NATIONAL PARK [a]

STOCK	YEARS	TOTAL RIVER RETURN	RIVER CATCH COMMERCIAL	RIVER CATCH SPORT	ESCAPEMENT	COMMENTS AND SOURCE[i]
COHO						
Ozette, F	1973-81		c	c		Blum 1982 per. com.
* Quillayute, SU	1973-81			0.1±0.1(0.05-0.04)	0.9±0.3(0.6-1.3)	Wood 1982 per. com.
Quillayute, F	1974-81			0.4±0.2(0.2-0.6)	8.0±5.7(3.1-20.4)	Wood 1982; WDF 1982a.
* Hoh, F	1974-81		1.1		2.8±1.1(2.1-5.2)	Com. catch for 1980 and 1981 only. Jorgensen per. com. WDF 1982a.
* Queets, F	1974-81		1.6±.7(0.8-2.7)	b	4.0±2.5(1.5-8.5)	Catch for 1976-80; QFiD 1982a. WDF 1982a
* Quinault, F	1978-81		4.4±2.6(2.6-8.2)	c	5.7±4.1(2.7-11.4)	Preliminary estimates. Gilbertson per. com.
CHINOOK						
* Ozette, F	1973-81		c	c		33 fish com. catch, 1975; 0, other years. Blum 1982 per. com.
Quillayute, SU	1980-81			0.2±0.2(0.1-0.5)	0.6±0.1(0.6-0.7)	Sport catch for 1976-81; Wood 1982 per. com. QTF 1981.
* Quillayute, F	1968-80	6.4±1.6(3.9-9.2)		0.5±0.1(0.3-0.6)	3.5±1.4(2.1-6.8)	Sport catch for 1976-81; Wood 1982 per. com. QFiD 1982ac, QTF 1981.
* Hoh, SP/SU	1973-81	1.9±5.0(1.2-2.8)	0.7±0.3(0.2-0.8)	0.2±0.2(0.1-0.4)	1.0±0.4(0.5-1.6)	d, e. HTF 1982a
" , F	1973-80	2.4±1.1(1.7-4.5)	1.0±0.6(0.5-2.3)	0.2±0.1(0.1-0.3)	1.3±0.7(0.5-2.2)	d, e. HTF 1982a.
* Queets, SP/SU	1969-81	1.6±.6(0.8-2.9)	0.6±0.4(0.1-1.4)	0.2±0.1(0.1-0.3)	0.8±0.4(0.5-1.5)	d, e. QFiD 1982abc.
* Queets, F	1967-80	5.7±2.0(2.5-10.2)	2.7±1.3(.9-5.5)	b	2.9±1.2(1.2-5.7)	Sport catch 36±12 fish/year, 1977-80. QFiD 1982abc.
* Quinault, SP/SU	1975-81		0.2±0.1(0.04-0.34)	c		River run estimated at <1,500; f. QFiD 1982ab.
* Quinault, F	1980-81		1.4±0.2(1.2-1.5)	c		Gilbertson 1982 per. com.
SOCKEYE						
Ozette	1973-81		b	c	2.4 for 1982	Catch averaged about 30 fish/year. Wood 1982; Blum 1982 per. com.
Quillayute	1975-80		c			2±3 fish caught/year. QTF 1979, 1980.
Hoh	1974-80		c			3±4 fish caught/year. HTF 1981.
Queets	1974-81		b			Lestelle 1982 per. com.
* Quinault	1973-80	60.1±32.4(27.6-134.3)	24.9±21.3(4.7-73.8)		36.8±17.5(15.2-60.8)	Includes some hatchery returns, Table 8. QFiD 1981b.
CHUM						
Quillayute	1974-80		0.3±0.3(0.1-1.0)			QTF 1979, 1980.
Hoh	1974-81		0.1±0.04(0.04-0.2)			HTF 1981.
Queets	1974-81		0.2 Est.			Lestelle 1982 per. com.
Quinault	1967-72		0.7±0.4			Essentially a hatchery run after 1976, Table 8. Gilbertson 1982 per. com.
PINK						
Quillayute	1975-80		b			19±39 fish caught/year. QTF 1979, 1980
Hoh	1974-80		c			3± fish caught/year. HTF 1981.
Queets	1974-80		c			Run estimated at < 300/year. Lestelle 1982 per. com.
Quinault	1974-80		c			" " " " "
STEELHEAD						
* Quillayute, W	1977-79		0.5±0.7(.05-1.4)	1.0±.6(.3-1.4)	6.4±1.3(5.5-7.8)	Escapement for 1979 only, 44% of spawning in Soleduck R. QTF 1981. WDG 1978b. 1979.
* Hoh, W	1976-81		1.1±0.4(0.7-1.5)	0.6±0.2(.5-.8)	1.5±.5(.8-2.1)	Sport catch for 1980-82 only, Jorgensen 1982 per. com. HTF 1982.
* Hoh, SU	1975-78		b	b		Com. catch of 40/year; sport 70/year, g. HTF 1982a.
* Queets, W	1972-81	9.9±3.3(6.7-16.6)	4.8±2.9(.7-10.5)	0.3±0.2(.1-0.7)	4.8±2.0(1.6-8.2)	QFiD 1981c.
* " , SU	1977-80		b, g	0.2±0.1, g		Lestelle 1982 per. com. WDG 1977-80.
* Quinault, W	1978-81	7.8±1.4(5.9-8.9)	2.5±1.4(.7-3.7)	0.8±0.7(.2-1.4)	4.6±0.5(4.1-5.1)	Upper River has 29% of spawning and sport catch of 120 fish/year. QFiD 1981c.
* Quinault, SU			h	c, g		Gilbertson 1982 per. com. WDG 1977-80.

a. Mean ± standard deviation (range), thousands of fish. F = Fall, SU = Summer, SP = Spring, W = Winter.

b. Fewer than 100 fish per year average, see comments.

c. Fewer than 10 fish per year average, see comments.

d. Jacks included in sport catch.

e. Ceremonial and subsistence included in commercial.

f. Includes some hatchery fish, 1978-80.

g. Catch dominated by hatchery fish of unknown origin after 1979.

h. 200-300/year after 1979, but mainly of hatchery origin.

i. WDF = Washington Dept. of Fisheries.
WDG = Washington Dept. of Game.
QTF = Quileute Tribal Fisheries.
QFiD = Quinault Fisheries Division.
HTF = Hoh Tribal Fisheries.

*Stocks of major concern to Olympic National Park

ranged upward to a few hundred fish each. Recent catches have been dominated, however, by straying hatchery fish of largely unknown origin.

The combined annual escapement for the 35 stocks listed in Table 3 probably exceeds 90,000 fish. In addition to these stocks and waters, at least 10 small streams originate in or cross the coastal strip of ONP to discharge directly into the Pacific Ocean. These are thought to contain coho stocks; at least four are known also to support winter steelhead. Further, each of the five major drainages and the 10 small streams likely contain anadromous cutthroat trout and, perhaps, Dolly Varden stocks of largely unknown size. The Quillayute, Hoh, Queets and Quinault rivers are known, however, to support sizeable cutthroat stocks. Counting the fish in coastal streams as small separate stocks and guessing largely at the distribution of cutthroat trout and Dolly Varden, means that 70 or more stocks of wild native anadromous salmonids occur at least in part within the boundaries of ONP. Only about 30% of these stocks would be considered significant either commercially or to recreational fishermen, but all contribute to the biological diversity and interest of the park.

The sources and accuracy of the information in Table 3 require explanation. The many blank spaces in the table occurred where escapement was not estimated for small stocks, where the proportion of hatchery to wild fish could not be determined in the catch, or where catch and escapement data were available for different periods. Estimates of sport catches are mostly expanded from punch card reports. Only 15-35% of the Washington State steelhead anglers return punchcards. Successful fishermen are more likely to return cards than unsuccessful anglers (WDG 1979). Periodic creel censuses may be conducted to

correct some of the reporting biases in returns. The estimates of sport harvest are considered here to show only approximate numbers removed. Recent commercial catches are generally tallied from records of fish buyers. This accounting has reportedly become more accurate over the past decade (Jorgensen 1982 per. com.). Indian subsistence and ceremonial catches often are estimated by contacting tribal members (HTF 1982a).

Recent escapements have been estimated by a variety of methods of variable accuracy (Table 4). Terminal run size has been estimated by using catch/effort (C/E) models. Escapement can then be calculated from the run size estimates by using the ratios of hatchery to wild fish in the catch and the known hatchery return. Escapements for 12 stocks are estimated from redd counts (tallies of the nests made by spawning females); sometimes in combination with C/E models. Procedures used in redd counts and the expansions necessary to estimate total escapement differ among stocks, and are outlined in detail in reports of the Quinault and Hoh Tribal Fisheries Departments and Washington Department of Game (1978). Counts are made by air, by foot or by boat and may be expanded to cover areas that are not surveyed or surveyed less frequently. The estimates of the total numbers of redds are expanded to give escapement by adding the proportion of males assumed or sampled in the population. Personnel involved think that, because of river flows, and time and site of spawning, the accuracy of escapement estimates is potentially greatest for steelhead and spring chinook; lowest, for coho and fall chinook (Lestelle, Jorgensen 1982 per. com.). Understandably there may still be considerable error in all estimates. Apparently, no successful independent estimates have been attempted to determine the accuracy of escapements derived from redd counts. These could possibly be done using mark recapture techniques and perhaps weirs (See

TABLE 4. PROCEDURES USED TO ESTIMATE ESCAPEMENT AND DATA AVAILABLE TO ESTIMATE "OPTIMUM" ESCAPEMENT FOR 18 WILD SALMONID STOCKS

Stock	Years	Escapement	Comments[b]	Source
COHO				
Quillayute, SU	1973-82	Redd counts expanded from index areas.	Methods to estimate optimum escapement are in dispute for all coho stocks, see text.	Wood 1982 per. com.
Quillayute, F	1978-82	Redd counts on index areas and in-season C/E estimation models.[a]	1974-77, assumed gill net exploitation rates applied to commercial catch to estimate escapement.	Wood 1982 per. com.
Hoh, F	1980-82	Redd counts on index areas.	1973-79 escapement estimated from assumed gill net exploitation rates and C/E models. Data generally considered poor.	Jorgensen 1981, Wood 1982 per. com.
Queets, F	1974-82	Redd counts on index areas.		QFiD 1981a, 1982a.
Quinault, F	1978-82	Estimated from ratio of hatchery to wild fish in catch, known hatchery return, and C/E.	Springs managed primarily as a hatchery stock.	Gilbertson 1982 per. com.
CHINOOK				
Quillayute, SP/SU	1980-81	Expanded redd counts.	Managed primarily as a hatchery stock.	QTF 1982.
Quillayute, F	1973-80	C/E model using Quileute hatchery rack recovery. 1980 estimate from redd counts.	Preliminary S/R relationship for 1968-80[a]	QFiD 1982a, c.
Hoh, SP/SU	1975-80	Estimated from redd count.	Preliminary S/R relationship for 1968-80. Assumed gill net exploitation used to estimate escapement for 1973-74.	QFiD 1982c, HTF 1982a.
Hoh, F	1975-80	Various C/E estimates and redd counts.	Preliminary S/R relationship for 1967-80. Redd counts often poor. Assumed gill net exploitation rates used to estimate escapement prior to 1980.	QFiD 1982c, HTF 1982a.
Queets, SP/SU	1976-80	Redd counts of increasing quantity.	Preliminary S/R relationship for 1969-81.	QFiD 1982c.
Queets, F	1973-80	C/E model using assumed exploitation rate.	Preliminary S/R relationship for 1967-80.	QFiD 1982c.
Quinault, SP/SU	1981	Prelim. in season C/E model.		QFiD 1982a.
Quinault, F		?	Managed as a hatchery stock. An "early wild" run is composed of fish 1-2 generations removed from hatchery; "late wild" fish are identified by run timing and age composition.	Gilbertson 1982 per. com.
SOCKEYE				
Ozette	1982	Weir count of 2119 expanded to 2400.		Blum 1982 per. com.
Quinault	1921-25	From weir counts at L. Quinault.	S/R relationships expanded for 1908-80 These suggest that for present conditions MSY occurs at escapement of <25,000.	QFiD 1981b.
STEELHEAD, W				
Quillayute	1979-81	Prelim. redd surveys.	Surveys not corrected for aerial efficiency.	QTF 1982.
Hoh	1976-81	Redd counts of increasing quality.	Prelim. S/R relationship for brood years 1976-79.	HTF 1982a, b.
Queets	1974-81	Redd counts of increasing quality.	Prelim. S/R relationship for brood years 1972-76.	QFiD 1981c.
Quinault	1981-82(?)	Redd counts.	Escapement 1976-80 estimated from exploitation rates, hatchery returns and age composition data.	QFiD 1981c.

a. C/E = catch per unit effort; S/R = spawner recruit relationships.

b. Comments include an assessment of data available to estimate "optimum" escapement.

Olney 1976, Eames and Hino 1981). The accuracy of coho escapement values based upon assumed exploitation rates or upon redd counts is unknown, but redd counts might be ± 50% if expanded from counts of index areas (Workshop for Spawning Escapement Policies-Washington Coastal Coho 1982). The 1973-82 escapements for Quinault sockeye were from hydro-acoustic counts of Lake Quinault; several early counts of escapement for this stock were made at weirs. The 1982 count of Ozette sockeye was also of fish passed around a weir. Clearly, there are real, but largely undefined, limits to the accuracy of the techniques used to estimate escapements, and the values in Table 3 are considered here to represent only approximate levels of escapement. Hope for increased accuracy may lie in the development of riverine acoustic counters now under test (QFiD 1982a:84).

Stock Distribution. The general distribution of spawning for the native wild stocks of salmon and steelhead within and adjacent to ONP is shown in Figs. 2 to 5, tallied in detail in Appendix Tables II to V, and summarized in Table 5. These data were provided mainly by fisheries biologists of the Quileute, Hoh and Quinault tribes and the Washington Department of Fisheries (sources listed in Tables II to V). Some data on salmon distribution in the small streams of the coastal strip were taken from the WDF Stream Catalogue (WDF 1975). Coho distribution in the Quillayute River was taken from QTF (1982). Data on coho distribution for some tributaries of the Hoh were from an early undated map provided to the park by WDF. The information on spawning distribution comes mainly from redd counts used to estimate escapement, from studies of juvenile abundance and distribution, and from stream surveys. Fish distributions were drawn on a 1:62,500 scale map. Approximate river miles used by spawning fish then were determined from the Stream Catalogue (WDF 1975) or measured directly from the map. Areas where a river or stream formed the park boundary were considered to be in the park. Information on drainages between the Queets and Quinault Rivers (e.g., Whale Creek, Raft River) was not included because these drainages are entirely outside park boundaries.

It must be emphasized that these maps show only the overall distribution of known spawning activity, and are viewed as crude first approximations. Fish distribution may differ annually because of river flows, population density, etc. Maps show the usual upstream limits of penetration by spawning fish. For some stocks the spawning area shown is overestimated, because local habitats unsuited for spawning (poor quality gravel, bedrock) are included. This may be especially true for spring/summer chinook use of the mainstems of the Quillayute drainage. The stock's distribution is patchy and variable from year to year in

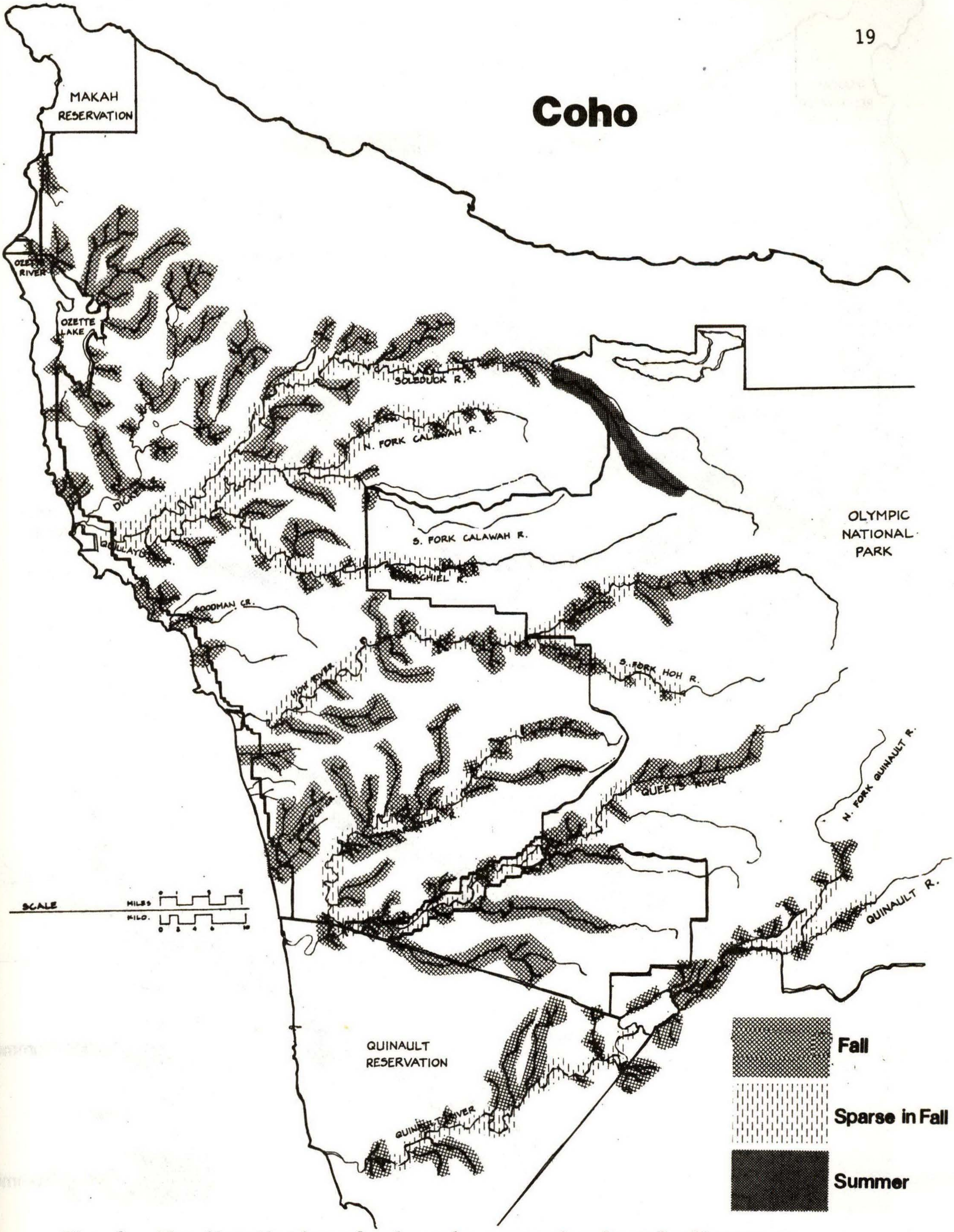

Fig. 2. The distribution of coho salmon spawning in and adjacent to Olympic Park. "Sparse in Fall" indicates spawning in spring creeks and terrace tributaries along mainstems.

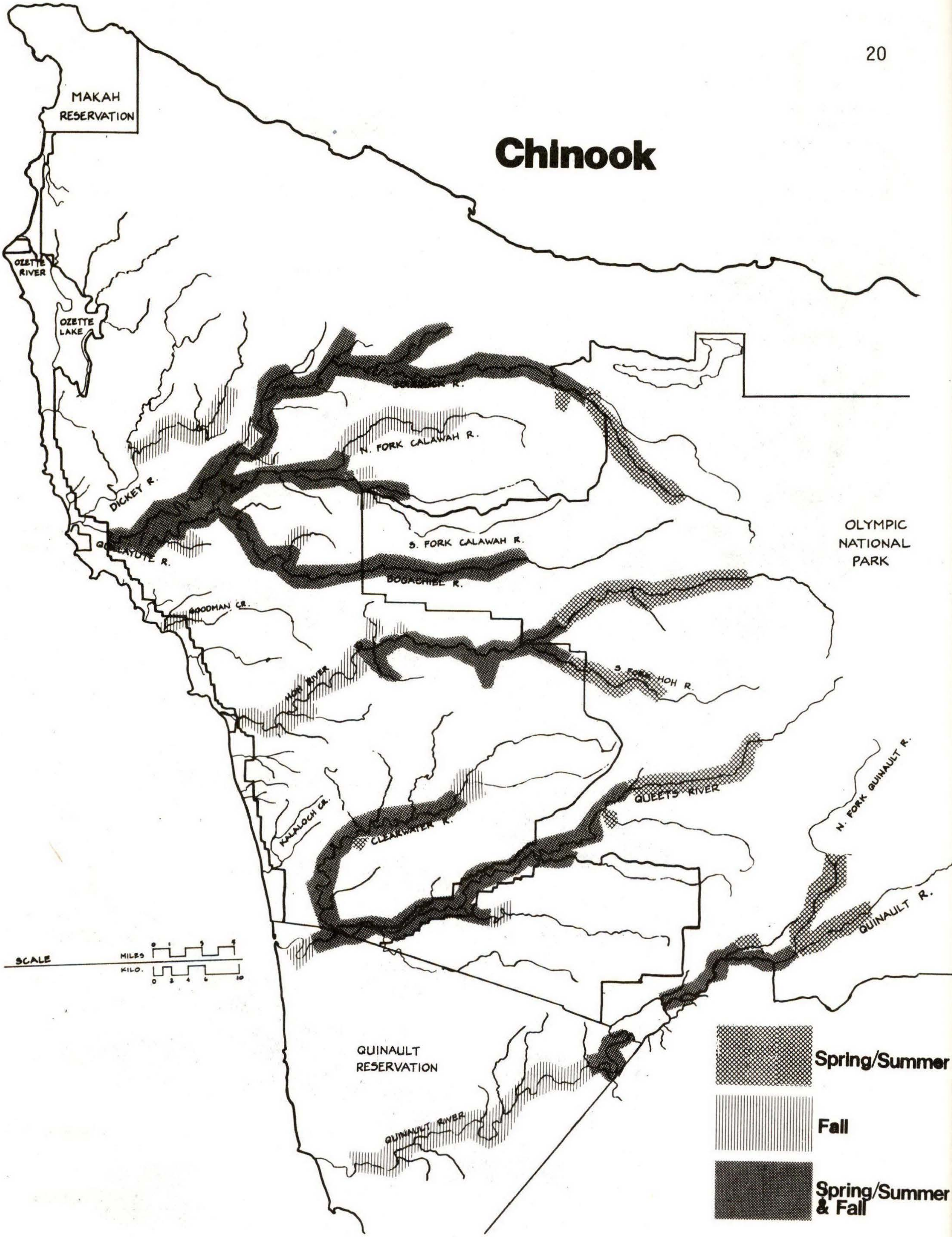

Fig. 3. The distribution of chinook salmon spawning in and adjacent to Olympic Park.

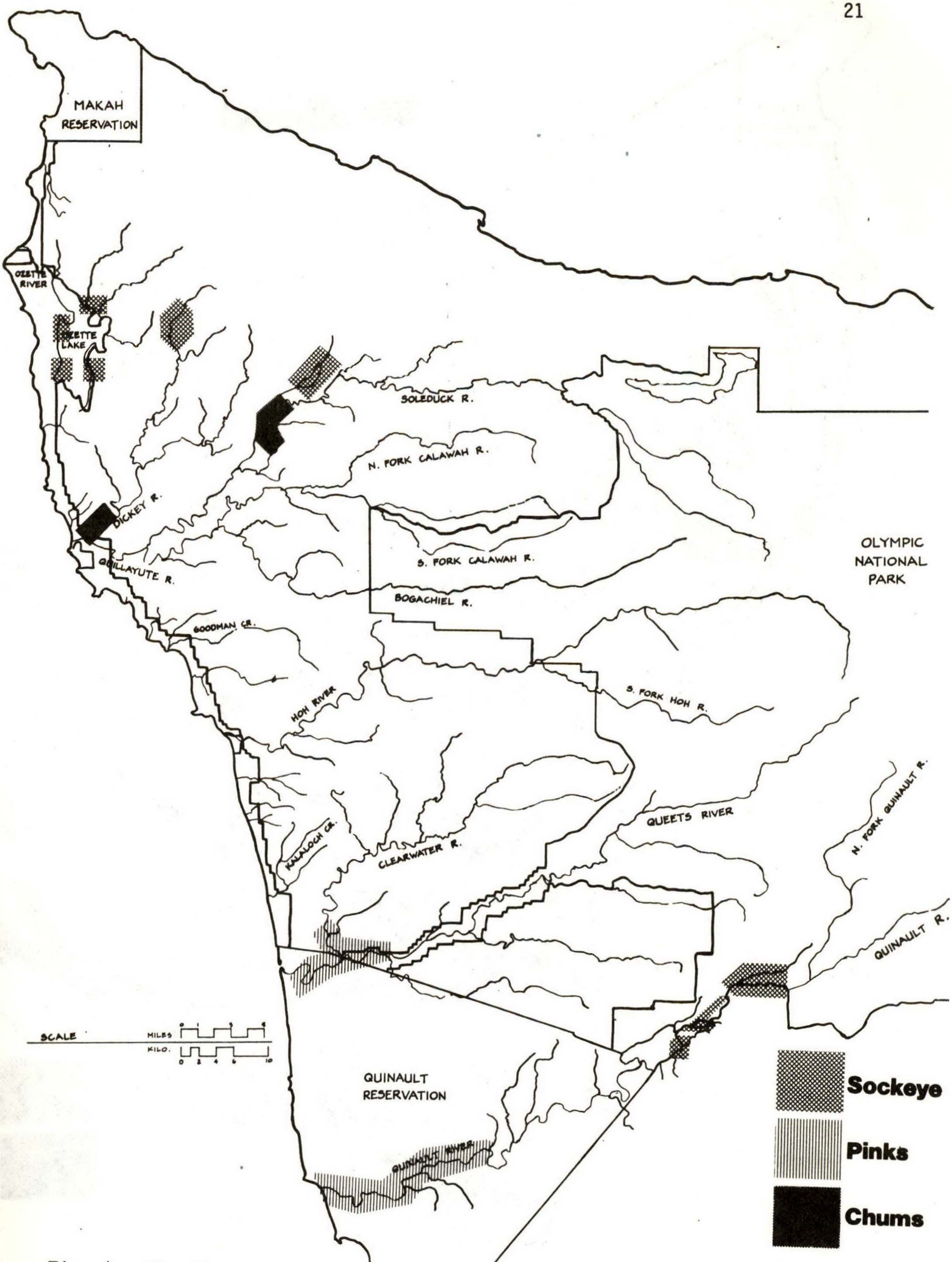

Fig. 4. The distribution of sockeye, pink, and chum salmon spawning in and adjacent to Olympic Park.

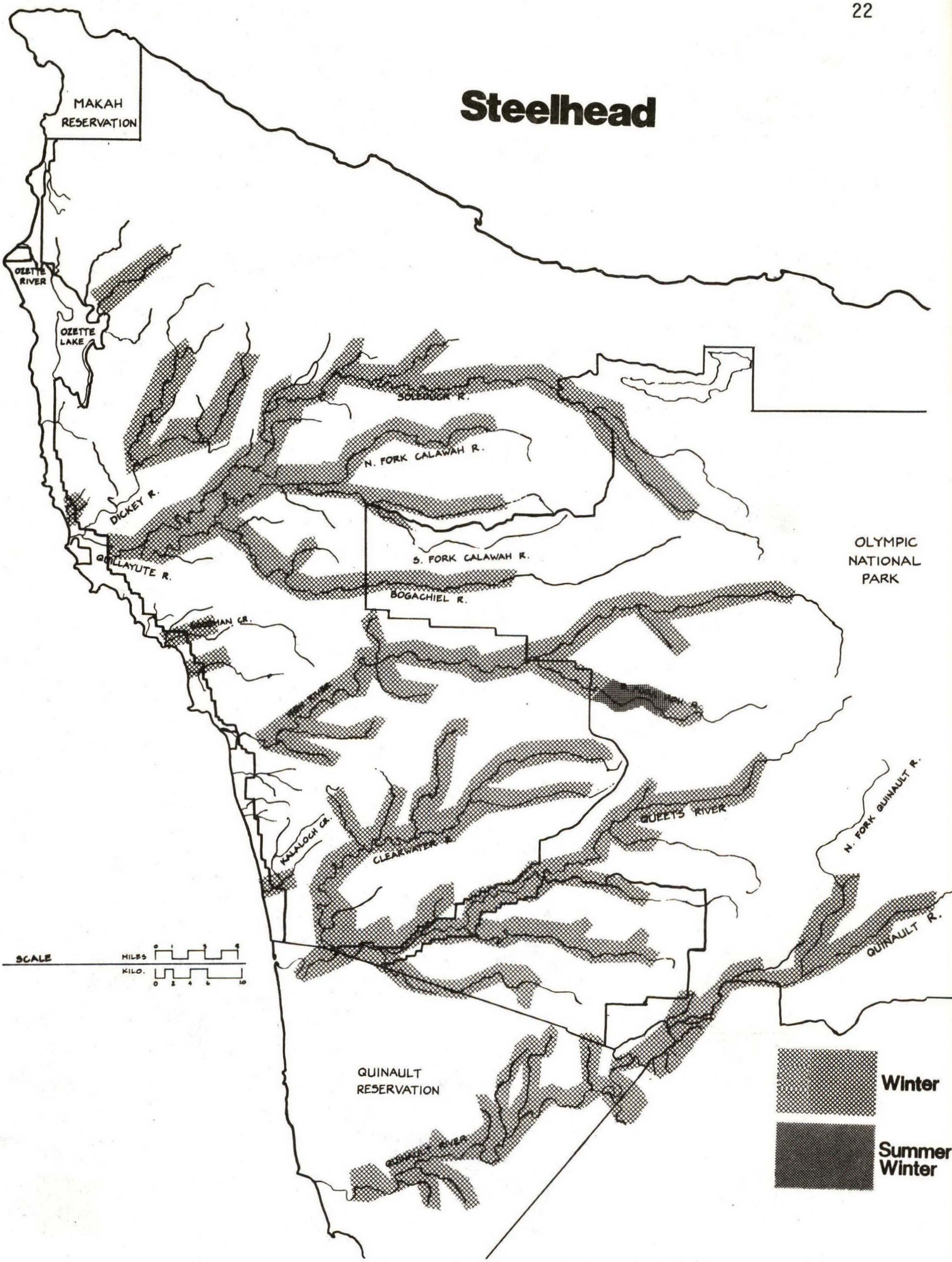

Fig. 5. The distribution of steelhead spawning in and adjacent to Olympic Park.

TABLE 5. Summary of the distribution of spawning by 6 salmonid species within and adjacent to Olympic National Park [a/]

		RIVER MILES UTILIZED FOR SPAWNING			
LOCATION	STOCKS	OUTSIDE PARK	INSIDE PARK	(%)	TOTAL
Ozette	Coho, Fall	47	7	(13)	54
	Chinook, Fall	1	3	(75)	4
	Sockeye	2	-		2
	Steelhead [g/]	6	?		?
Quillayute	Coho, Summer	*	15	(100)	15
	Coho, Fall	149	5	(3)	154
		(252) [b/]	(14)	(5)	(266)
	Chinook, SP/SU	102	20	(16)	122
	Chinook, Fall	133	17	(11)	150
	Sockeye	d/	d/		d/
	Chum	6	*		6
	Pink	d/	d/		d/
	Steelhead	175	31	(15)	206
Hoh	Coho, Fall	33	21	(39)	54
		(63)	(49)	(44)	(112)
	Chinook, SP/SU	22	26	(54)	48
	Chinook, Fall	47	3	(6)	50
	Sockeye	d/	d/		d/
	Chum	e/	-		e/
	Pink	d/	d/		d/
	Steelhead	49	31	(39)	80
Queets	Coho, Fall	80	26	(25)	106
		(130)	(64)	(33)	(194)
	Chinook, SP/SU	29	39	(57)	68
	Chinook, Fall	42	32	(43)	74
	Sockeye	d/	d/		d/
	Chum	d/	d/		d/
	Pink	7	3	(30)	10
	Steelhead	117	55	(32)	172
Quinault	Coho, Fall	52	20	(28)	72
		(81)	(44)	(54)	(125)
	Chinook, SP/SU	6	30	(83)	36
	Chinook, Fall	32	13	(29)	45
	Sockeye	4	7	(64)	11
	Chum	f/	-		f/
	Pink	11	0		11
	Steelhead	76	38	(33)	114
Misc. Coastal [c/] Streams	Coho, Fall	22	14	(39)	36
	Chinook, Fall	*	2	(100)	2
	Steelhead	4	6	(60)	10

a. Detailed data and sources in Tables II to V.
b. Estimate includes mainstem and represents additional spawning and rearing areas.
c. From Petroleum Cr. south to Kalaloch Cr.
d. Very small stocks, see Table .
e. Sporadically\in mainstem below Owl Cr. NPS jurisdiction limited to coastal strip.
f. Sporodically in mainstem and lower tributaries to about 4 miles above Lake Quinault.
g. Primarily winter run.
* Less than 1 mile.

the general area shown in Fig. 3. Spawning distribution overlaps extensively in space with fall chinook.

Maps could be refined considerably as more information on density of spawning fish becomes available. Maps showing average numbers of spawning fish/mile would be particularly useful, and would give a much clearer picture of stock separation, i.e., spatial overlap in the distribution of spring/summer with fall chinook on the Quillayute may not be as extensive as suggested. A further refinement would be to relate spawning densities to the subsequent standing crop or production of juveniles. Production per spawner likely varies considerably within a drainage and conceivably could be either higher (because of pristine habitats) or lower (harsher environments) in the upstream areas of the park. These caveats considered, the maps and calculations, in combination with estimates of stock abundance (Table 3), provide a first perspective on the extent of ONP stewardship responsibilities for these anadromous stocks.

Coho show the broadest distribution of spawning of the five salmon species (Fig. 2). Fish spawn in tributaries to major rivers, in spring creeks and terrace tributaries and in short coastal streams throughout the area. Their distribution proved to be particularly difficult to map or calculate. Tabulations of the spawning that occurs in just the tributaries underestimates distribution because spring creeks and terrace tributaries are too small to map. If the mainstem mileage estimates are included, the spawning area is overestimated. The mainstem and tributary mileages combined do, however, give a reasonable estimate of the amount of juvenile rearing habitat. Side channels and other areas along mainstems may be used extensively by juvenile coho (See Sedell 1982 et al.). The extent to which mainstems are used for rearing by

coho in coastal rivers is in dispute. Mainstem rearing occurs in the Bogachiel (WDF 1982b). The data on distribution and abundance suggest that ONP has a major responsibility for the summer coho on the Quillayute, and should have a strong interest in the welfare and management of fall coho on the Hoh, the Queets (excluding the Clearwater) and the upper Quinault Rivers.

Chinook spawn in mainstems and larger tributaries of the major rivers (Fig.3). Spring/summer stocks tend to occupy areas upstream from fall stocks but, as discussed above, there is considerable spatial overlap. Spring/summer chinook stocks on the Hoh, Queets and Quinault are of major concern to ONP. Stocks on the Bogachiel and upper Soleduck are of lesser concern. Spring chinook are grouped for management convenience with summer chinook, and the distribution of these two forms in the rivers is poorly understood. Spring chinook on the mainstem Hoh (April-mid June river entry) are thought to spawn farthest upstream, from River Mile 35-47.5 and on 9.5 miles of the South Fork Hoh (Jorgensen 1982 per. com.). These fish occur primarily in the park. It may be that the spring groups are of primary concern to ONP on all the drainages, even though they are not generally recognized or managed as separate stocks. (Summer run fish would still be of major concern to ONP on the Queets River.)

Fall chinook spawn from near tidewater throughout the lower and middle mainstem areas. Except for the Queets River and short areas of the Bogachiel and upper Quinault, major fall chinook stocks are of less direct concern to ONP than the spring/summer stocks. (Indirectly, all stocks are still of concern to NPS since the management and harvest allocations on a stock that occurs entirely outside park boundaries often affects the management of other stocks within the park.) Nearly 80% of the fall chinook spawning on the Queets (excluding the Clearwater)

occurs within the park. Fall chinook distribution on the Ozette drainage is poorly understood, but this small stock may be of major concern to the NPS.

Known sockeye spawning in the Ozette drainage occurs presently along the lake shore (Blum 1982 per. com., Fig. 4) and is outside the park (waters of the lake are outside NPS jurisdiction). Small stocks of possible river spawning sockeye are known to occur in the park on the Quillayute, Hoh and Queets rivers. Apparently, a substantial proportion of the abundant Quinault sockeye spawn within the park. A preliminary survey of spawning habitat suggested that over 50,000 meters^2 of suitable spawning habitat occurs above Lake Quinault (WDF 1981). In the view of WDF, this habitat is "underutilized," i.e., calculated mean densities of 0.46 spawning females/m^2 is slightly more than one-half of the densities (0.80/m^2) thought to be optimum elsewhere (QFiD biologists contest this interpretation).

Chum salmon spawning in ONP is limited largely to the Queets River and to small areas on the lower Hoh and the Quinault above the Lake (Fig. 4, Table IV). Pink salmon spawning is even more limited, and is of interest mainly on the Queets and Hoh rivers.

Steelhead are known to spawn throughout the mainstems and tributaries of the major drainages and in several coastal streams (Fig. 5). Little is known about separation of summer and winter stocks (see below). They are generally combined for this discussion, but summer stocks are <u>very</u> small compared to wild winter run stocks (Table 3). The NPS has a major direct interest in the Queets River stocks and in stocks in the upper Soleduck, upper Bogachiel, upper Hoh, and in the Quinault above the Lake. Summer steelhead are known to spawn in a small area of the South Fork Hoh within the park. It may be that

the small summer stocks on the mainstem Hoh and in the Queets and Quinault rivers spawn primarily within ONP.

To summarize, the data available on distribution and abundance of the major stocks of wild native salmonids (i.e., those with escapements of 500 + fish in Table 3) suggest that ONP has a special interest in the management of: summer coho on the Quillayute; fall coho on the Hoh, the Queets, and the upper Quinault; spring/summer chinook on the Hoh, Queets, and upper Quinault (the spring runs may be of special interest); fall chinook on the Queets (particularly), the upper Quinault, and perhaps the Bogachiel; Quinault sockeye; winter steelhead on the Queets, and on the upper reaches of the Soleduck, Bogachiel, Hoh and Quinault rivers. In addition to these 15 comparatively large stocks (the Soleduck and Bogachiel steelhead counted here as one Quillayute River stock) the small stocks of wild summer steelhead on the Hoh, Queets and Quinault could be of interest because they may occur primarily within the park. The distribution of fall chinook on the Ozette River is poorly known, and that small population may occur primarily within the park. Of the 70 or so possible wild stocks that occur within and adjacent to ONP, these 19 represent the focus of preliminary NPS attention. The combined annual escapement for these stocks approaches 75,000 fish. This list is refined below, following consideration of hatchery stocks. In many cases, the stocks of primary concern to the NPS are the least abundant of two stocks of the same species in a river (summer coho, spring/summer chinook and perhaps summer steelhead). Consequently, comparatively little is known about their distribution, abundance and life history.

Trends in Abundance. The records available to assess trends in abundance for the salmonid stocks of interest to ONP consist mainly of tallies of commercial harvests. Trends in run size and escapement may be inferred if exploitation rates and age composition can be calculated. Gilbertson (1977, 1981) examined narrative accounts of salmon abundance from the 1860s-1900s, and analyzed harvest records for Quinault sockeye for 1908-1980. Estimates of escapement and return/spawner values were derived and then used to develop stock/ recruitment relationships. He reports that a "striking feature of this harvest history are the extremely large catches prior to 1950, the decline in harvest after 1950 and the cyclic nature of harvest patterns. The cycles are not constant but are approximately 7-9 years between large harvests (>100,000). This pattern is related to the predominance of 4 and 5 year old age classes and an inverse relation between escapement and return per spawner." Annual harvests exceeded 100,000 fish during 17 years from 1908-1950; were over 200,000 during 8 years and exceeded 500,000 in 1941. Gilbertson (1981) states, "Total annual runs of Quinault sockeye are not as large as they were prior to 1950. This is related to a decrease in the underlying stock productivity at all levels of escapement. The loss of productivity was at least partly caused by a loss of spawning habitat and hatchery production." The upper Quinault river is thought to have become more unstable during this period and a substantial fish hatchery operated on the river from 1914-47. Gilbertson's account represents the most thorough analysis of the population dynamics and trends for any of the coastal stocks of concern to ONP.

The information available for other salmon stocks appears to be far more limited and consists mainly of records for the tribal net fishery of variable quality,

beginning during the mid 1930s or 1940s. Preliminary analysis and interpretations of harvest trends by drainage are found in: Dlugokenski et al. 1981 (for Ozette) Quileute tribal fisheries 1978; Hoh tribal fisheries 1980-82; Quinault tribal fisheries 1977; and Wood (1978) for major coho stocks from 1950-77. Briefly, chum harvests declined dramatically for all coastal rivers from the Ozette to the Quinault during the 1940s and 1950s. Reported harvests on the Queets and Ozette Rivers, which would have been of particular concern to ONP, averaged about 1890 ± 1700 SD (1935-50) on the Queets and declined to about 200 (Table 3). Harvests declined on the Ozette from about 900 ± 300 (1948-55) to zero today. Sockeye catches on the Ozette also declined dramatically during the 1950s. Generally, these declines are attributed to some combination of increased fishing and habitat degradation resulting mostly from logging and associated road building.

Trends in coho and chinook stocks are more difficult to interpret because increasing numbers have been caught by trolling fleets at sea. A reduced river catch does not necessarily reflect either reduced total harvest or a drop in productivity, only that the fish may be caught elsewhere in mixed stock fisheries (See Quinault Tribal Fisheries 1982c, Wright 1976, Wood 1978). Major reviews of trends in coastal coho and chinook stocks are nearing completion (Wood 1982, per. com., Salo 1983 In prep.).

Preliminary reports of trends in winter steelhead stocks from about the mid 1940s are available for the Quillayute (QTF 1977), Hoh (HTF 1980-82), Queets and Quinault Rivers (QFiD 1977). Commercial catches of the Hoh River steelhead, of particular interest to ONP, are interpreted as relatively stable at around 2400 ± 700/year from 1948-63. Catch data for 1964-68 and 1970

are unavailable. Reported commercial catches for the Queets were around 3800 ± 2700 from 1944-64 (1950-53 unavailable), with a peak catch in excess of 13,000 for 1954 (QFiD 1977). Recent trends will be even more difficult to interpret for some stocks because hatchery and wild fish have not been reported separately in the catch until just the past few years. Also, tribal fisheries at the river mouths sometimes take substantial numbers of hatchery steelhead ultimately bound for other rivers (See QFiD 1981c).

With the outstanding exception of Quinault sockeye, the available interpretations of harvest trends usually begin in the mid 1930-1940s, perhaps 40 years after commercial harvests were intensified by Indian and Euro-American fishermen. [Aboriginal man occurred on the Olympic Peninsula 12,000 years before present (BP); cultures based heavily upon salmon had developed on the Columbia River and around Puget Sound by perhaps 8000 BP (Borden 1979).] More work will be needed to refine and perhaps extend estimates of trends in abundance for selected stocks of interest to ONP. Mullens (1981a,b), for example, estimated trends in abundance for Oregon coastal coho stocks from 1892-1960 using a combination of cannery and landing records. Despite problems inherent in interpreting early records, escapement for Oregon coastal coho apparently declined from nearly 1 million shortly after the turn of the century to fewer than 100,000 by the late 1970s. A quick review of the sources used by Mullens provided a perspective on early cannery operations on the coastal rivers. Canneries were built on the Hoh in 1917, on the Queets in 1905, and at Moclips near the Quinault in 1911 (Cobb 1930). Records of the number of cases packed are available by species for individual rivers from 1911 or 1917 until about 1927. Calculated numbers of fish canned per year (Table 6) indicate the magnitude of early

TABLE 6. Calculated historic packs of canned salmon and steelhead from three coastal rivers.[1]

River	Date	Species	No. Fish Canned/Year[2] Mean	Maximum
Hoh	1917-21[3]	Chinook	870	1,700
		Coho	2,750	3,700
Queets	1912-27[4]	Chinook	3,040	5,670
		Coho	13,000	24,980
		Chum	3,800	6,690
		Steelhead	3,430	9,150
Quinault	1911-25[5]	Chinook	3,490	16,250
		Coho	28,300	70,990
		Chum	17,730	44,320

1. All data from Cobb 1930.
2. Calculated from an average of 3.25 chinook, 9.99 coho, 6.56 chum and 6.10 steelhead for each 48 lb. case packed.
3. Coho and chum for 1917-20 only.
4. Packs reported for 12 years from 1912-27 for chinook; 11 years, 1912-26 for coh; 10 years 1912-26 for chum; 5 years, 1913-23 for steelhead.
5. Reported for 10 years from 1911-25 for chinook; 12 years, 1911-24 for coho; 11 years, 1911-25 for chum.

commercial harvests and are particularly interesting when compared to recent catches (Table 3). Coho and chum catches were markedly higher on the Queets and Quinault Rivers. These records could be refined to estimate run sizes and escapements, as for Oregon, if exploitation rates and tribal subsistence needs could be estimated. A more thorough account of stock trends, however crude, is more than an academic exercise for ONP because, unlike other areas where habitat degradation limits the usefulness of such data, the aquatic habitats remain in essentially pristine state. Alternatively, it might be possible to estimate pristine population levels from habitat characteristics, as recently done for the Elwha River (Chapman 1981). The main interest in this type of information is to provide a basis from which to assess the extent of the departures from pristine ecological conditions that have occurred, recognizing that full restoration is not possible.

Stock Status - Juveniles. Discussions of stock status, to this point, have focused primarily on the distribution, abundance, harvest and population trends of adult salmonids. Field studies of the juvenile stages (emergent fry to outmigrant smolt) of the life cycle of salmonids provide another source of information that may be particularly important to ONP. A partial list of the known studies and their results are summarized in Table 7. Many were management-oriented, as the primary purpose was to relate standing crop of juveniles or yield of downstream migrant smolts (juveniles adapting physiologically to life in saltwater) to the density of spawners -- and then to manipulate spawner density to maximize juvenile production. Preliminary attempts to use such data for setting coho escapements are reported in recent workshops (WDF and Quinault treaty tribes 1982).

Comparisons of standing crops are sometimes difficult because sampling methods differed among studies and in other cases the standing crop measurements included hatchery and wild fish. Nonetheless, the studies provided useful information on: life history (growth rates, outmigrant times and ages); limits to the upstream distribution of anadromous fish; fish community structure (density, biomass, species composition); and habitat use. These studies show that among salmonid species with extended freshwater rearing in tributaries and side channels, coho are generally the most abundant, followed usually by steelhead and then cutthroat.

In addition to the work in Table 7, the WDF has ongoing studies of juvenile coho and chinook salmon in preliminary stages of analysis. Chinook life history and production studies have been done on the Queets, Clearwater, Hoh and

TABLE 7. FIELD STUDIES OF JUVENILE WILD SALMONIDS IN AND ADJACENT TO OLYMPIC NATIONAL PARK

Drainage	Years	Objectives	Method[a/]	Report	Source
Ozette	1979	Smolt condition and outmigration.	Fyke net	Smolt outmigration for 1977 brood peaked in early May 1979. Smolts were large and in excellent condition.	Dlugokenski et al., 1980.
Quillayute	1978	Salmonid standing crop.	E^- fishing	Coho averaged $.162\pm.070/m^2$; steelhead age 0, $.069\pm.052/m^2$; age 1, $.010\pm.003/m^2$ on 6 tributary streams.	WDG 1978.
	1979-81	Migration and rearing	Seine	Standing crop of salmonids, growth rate and food habits sampled in estuary. Peak use of estuary by 0+ chinook was May-Sept.	Chitwood 1981, QFD 1981, 1982.
	1981	Distribution and abundance	E^- fishing	Distribution anadromous fish sampled in 7 tributaries of upper Bogachiel, 6/22-26.	QFD 1982.
	1979-80	Migration time	Seine	Bogachiel mainstem sampled. Peak chinook outmigration occurred in May and June.	QFD 1979-81.
	1980-81	Habitat use	Snorkel and E^- fishing	Coho fingerlings occurred at a mean of 1.26/m in 1980; 0.58/m in 1981 in Bogachiel mainstem	WDF 1982b.
Hoh	1976-80	Salmonid standing crop	Seine	Density measured in 1-8 streams. Mean coho density ranged from $.014/m^2$ in 1976 to $.118/m^2$ in 1979; steelhead, $.016-.030/m^2$; cutthroat, $.009-.056/m^2$	HTF 1981.
	1976-80	Migration time	Traps	Numbers, size and time of outmigrant coho, steelhead and cutthroat monitored on 1-5 streams annually. Coho outmigration occurred mainly in May.	HTF 1981.
	1978, 80	Salmonid standing crop	E^- fishing and Seine	Distribution and density of coho, steelhead, cutthroat sampled by habitat type in S. Fork.	Sedell 1982.
Queets	1975-77(?)	Chinook life history	Traps	Periods of migration and size of 0+ age chinook monitored throughout. Mark and recapture estimate of 1,046,000 fall chinook fry produced in Queets above Clearwater during 1977.	QFiD 1976-77.
	1975-77(?)	Salmonid standing crop	E^- fishing	Density measured in 8 streams. Mean coho density $.296\pm.174/m^2$; steelhead $.192\pm.150/m^2$.	QFiD 1977.
	1980-81	Coho smolt production	Traps	Growth, migration times and no. smolts produced in 4 streams reported.	QFiD 1982a.
	1981	Habitat assessment	E^- fishing	Salmonid standing crop and distribution reported for 6 streams. Coho generally most abundant, $.230\pm.182/m^2$; steelhead, $.005\pm.005/m^2$, cutthroat $.062\pm.080$; 0+ trout, $.098\pm.079/m^2$.	QFiD 1982a.
Queets	1981	Salmonid standing crop	E^- fishing	Distribution and density of salmonids reported by habitat on upper Queets. Coho averaged 0.79, 0.21 and $0.03/m^2$ in tributaries, side channels and valley wall tributaries; steelhead 0.06, 0.12, $0.83/m^2$; cutthroat, 0.03, 0, $0.07/m^2$ respectively.	Sedell 1982.
Quinault	1973-77	Salmonid standing crop	E^- fishing	Density reported for 2-4 streams on upper river 1973-77. Coho most abundant at $.894\pm.380/m^2$; 1+ steelhead, $.129\pm.062\pm/m^2$.	

Bogachiel Rivers from 1975-82; on the Soleduck, 1976-82 (Peterson 1982 per. com.). Preliminary analysis suggests that the relationship between escapement and subsequent fry abundance is positive and relationships between indices of river discharge and fry abundance are negative (WDF 1982d, Wood 1983 per. com.). With four years data available, the relationship between fry abundance and subsequent river return appears to be positive (Wood 1983 per. com.). This is interpreted by WDF to suggest that adult escapement has been generally below the levels that produce the greatest quantity of outmigrant smolts. The standing crop of juvenile coho was measured in 6-8 streams at summer low flow from 1979-81(WDF 1982c). Calculations showed that coho densities averaged .667 $\pm$ .467, .630 $\pm$ .500 and .582 $\pm$ 400 fish/m^2 in 1978-80, respectively. Densities averaged 1.03 $\pm$ .223 fish/m^2 over the three years in streams where corresponding redd densities exceeded 8.6/mile, i.e., juveniles were thought to occur at "carrying capacity." WDF has additional samples of coho standing crop from sites without corresponding redd counts (Peterson 1982 per. com.). Finally, WDF operated smolt traps on the Bogachiel and Hoh Rivers in 1975-76 to mark wild fish. Smolts were trapped on the Quillayute drainage 1980-82 to measure smolt yield per unit area. Analyses of these data could add substantially to the biological information available for ONP salmonid stocks.

Reconnaissance surveys of fish distribution and community structure above and below barriers to anadromous fish were conducted in 1981 and 1982 on the Quillayute, Hoh, Queets, Quinault and Elwha drainages (Reisenbichler 1982). These studies will provide a background for detailed work on community structure and stock characterization. Also, the standing crop of juvenile steelhead was measured above Lake Quinault in 1982 as part of a study to evaluate the planting

of hatchery fish. Data are being analyzed (Huffman 1982 per. com.). Finally, an excellent series of studies on the early life history, standing crop, and effects of logging on salmonids has been conducted on the Clearwater River adjacent to ONP (See Cederholm and Salo 1979, Peterson 1980, June 1981).

Many of the studies reported here are in a preliminary or descriptive stage, rather than being available for guiding on-line management. A comment on the peculiar importance of these data to ONP management is prompted by this preliminary review. The juvenile stages generally represent the longest period in their life cycles that anadromous fish occur within the boundaries of the park. In the case of steelhead and coho this would be 1-2 years. By contrast, the spawning adults may be present for only a few weeks or months. Even though the numbers of spawning adults returning to the rivers are greatly below numbers that would occur without intense human predation, and most assuredly will be held at some lower level (See Management), the composition and structure of the juvenile communities <u>may be</u> much less altered. This is because a premise of anadromous fish management is that juvenile abundance can be maintained at high levels over a wide range of adult densities -- including greatly reduced numbers of spawners. It may be possible to maintain or restore some ecological processes characteristic of the pristine aquatic communities dominated by juvenile salmonids.

Hatchery Stocks. The origin, numbers of juveniles released, and numbers of returning adults caught for 27 hatchery produced salmonid stocks in and adjacent to ONP are summarized in Table 8. The establishment of large hatchery-based stocks is of particular concern to NPS because this may adversely affect remaining wild stocks. The potential effects of hatchery stocks on their wild counterparts depend upon the relative sizes of the two stocks, the nature of the hatchery operation (e.g., juveniles released directly from hatchery or "outplanted" throughout a watershed), the extent of straying, and the origin of the hatchery stock. Wild stocks may be adversely affected because of increased competition with hatchery juveniles for resources, but more often this results from the greater harvest rates usually imposed upon hatchery stocks (See Reisenbichler and McIntyre 1977, Wright 1981, Reisenbichler 1982). Hatchery coho stocks may be harvested at rates up to 95%, far higher than the 60-75% that can usually be sustained by wild stocks at optimum levels (Wright 1981). For example, all fall salmon and winter steelhead stocks on the Quinault River are currently managed primarily as hatchery stocks (QFiD 1981a, c, 1982a) and as a result, wild stocks may be deliberately (and appropriately by this philosophy) over-harvested (Wright 1981).

Hatchery stocks may be derived from wild native stocks or transferred in from other areas. Such stock transfers have at least the potential for altering the genetic makeup of the remaining wild stocks when returning hatchery adults also spawn in the wild (Helle 1976, Reisenbichler 1982). It is not entirely clear how effective some hatchery stocks are when spawning in the wild (in terms of supplying recruits to future adult populations) (Chilcote et al. 1981). Because of selection at the hatchery, these fish may return to the rivers and spawn earlier than their wild counterparts (See QFiD 1981c and HTFF 1982a). Since

TABLE 8. ESTIMATED CATCH, RETURNS, RELEASES, AND ORIGINS OF 27 HATCHERY PRODUCED SALMONID STOCKS IN AND ADJACENT TO OLYMPIC NATIONAL PARK [a]

STOCK	STOCK ORIGIN	RIVER CATCH YEARS	COMMERCIAL	SPORT	HATCHERY RETURN	NO./AGE FISH PLANTED, COMMENTS, AND SOURCE
COHO						
Quillayute, SU	Quileute	1976-81		0.3±0.3(0.1-0.7)	5.3±3.5(2.0-10.0)	1,351±394 yr, 1978-81; 406 fg, 1978; 727 fg, 1979. Wood 1982 per. com.; QFD 1981.
Quillayute, F	Soleduck (primarily)[b]	1976-81		0.1±0.05	2.7±2.4(0.1-5.5)	541±396 fry, 188±456 fg, 902±677 yr 1971-81. USFWS 1981, QFD 1981.
Hoh, F	Quinault/ Willapa (Primarily)[c]	1980/81	0.5±0.3(0.2-0.7)			156±80(100-300) yr, 1973-79. HTF 1982a.
Queets, F	Various[d]	1979-80	1.4±0.6(0.9-1.8)			250 fry 1974; 230±257(22-604) fg 1974-78; 342±220 (150-651) yr 1977-80. QFiD 1981a, USFWS 1981.
Quinault, F	Various[e]	1980	8.3			493±520 fg for 10 years 1964-79; 754±618(104-2, 115) yr 1969-80; misc. fry 1972-80. USFWS, QFiD 1981a.
CHINOOK						
Quillayute, SP/SU	Various[f]	1976-81		0.3±0.4(0.1-1.0)	0.9±0.9(0.2-2.7)	190±51 yr, 1973-78; 643±712 fg for 4 years, 1972-78; QFD 1981, USFWS 1981.
Quillayute, F	Soleduck[g] (Primarily)	1976-81		b	0.2±0.2(.03-0.4)	236±64 fg 1958-63, Dungeness; 420±405 fg for 4 years 1972-78; 60±43 yr 1973-78. USFWS 1981.
Hoh, SP/SU	Hoh (Primarily)		h			40.5±5.8 fg 1977-80; 100.0 Dungeness fg @ 500 lb. in 1960. HTF 1982a.
Hoh, F	Hoh (Primarily)		h			51.5±61(1.0-136.5) fg 1976-81; 168.5±88.8(94.6-267.) Dungeness fry @ 250/lb. 1957-59). HTF 1982a.
Queets, SP/SU	Cowlitz/ Soleduck		h			73 yr Cowlitz 1976; 204 yr Soleduck 1979. USFWS 1981.
Queets, F	Various[j]		h			169 fg 1978; 373 fg 1979; 21 yr 1976, 18 yr 1977. USFWS 1981.
Quinault, SP/SU	Cowlitz/ Soleduck		h			230±183 fg 1976-78. USFWS 1981.
Quinault, F	Various[k]	1980	4.3[l]			1,539 fg in 1968; 1,306±714 fg 1972-80. USFWS 1981.
SOCKEYE						
Ozette	Quinault/ and others					Records being compiled. Blum 1982 per. com.
Quinault	Quinault (Primarily)	(Adults returned at 0.014±0.019/smolt released 1973-76)				355±300 fg 1974-80; 230±65 fry 1975-77. QFiD 1981b.
CHUM						
Quillayute	Hoodsport/ Minter Cr.					7 fry, 1980; 75 fry 1963 Minter Cr. stock. USFWS 1981.
Hoh	Quinault/ Quilcene	1978-80				255±125 fry 1978-80; 3.0 fry Hoh R. stock 1976. HTF 1982a.
Queets	Quinault/ Quilcene	1978-80				710, 868, fry 1978, 1980. USFWS 1981.
Quinault	Quinault/ Quilcene	1977-81	7.4±5.0(3.1-13.8)			2,900, 2,000 fry 1979, 1980. Gilbertson 1982 per. com.; USFWS 1981.
STEELHEAD						
Quillayute, SU	Washougal/ Klickitat	1979-81	0.8±0.7(0.3-1.7)	1.7±0.3(1.5-2.0)		56±11 smolts 1977-78, 71; "Skamania" stock; WDG-1979-81, QFD 1981.
Quillayute, W	Chambers Cr. (Primarily)	1977-79	7.6±1.7(6.5-9.6)	1.9±1.9(0.2-4.0)		102±25 smolts 1972-79; 35±13 Soleduck smolts 1977-80 WDG 1979b. USFWS 1981.
Hoh, W	Chambers Cr. (Primarily)	1979-82	2.1±0.3(1.7-2.3)	0.9±0.2(0.7-1.2)		29±10 1962-78; 27±7 Hoh smolts 1978-81. WDG 1979b, HTF 1982a.
Hoh, SU		1979-81	0.5±0.3(0.4-0.9)	0.6±0.1(0.5-0.7[l]		Jorgensen 1982 per. com.
Queets, SU			<0.1[l]	0.2±0.1[l]		Lestelle 1982 per. com.; WDG 1979-81.
Queets, W	Quinault Queets	1978-81	1.6±1.2(0.6-3.3)	0.1±.08		2.9 hatchery strays spawned throughout, 1980-81. QFiD 1981c.
Quinault, SU		1979-81	0.2-0.3[l]	<0.01[l]		Gilbertson 1982 per. com.; WDG 1979-81.
Quinault, W	Quinault	1978-81	2.5±2.1(1.1-5.7)	0.4±0.4(0.1-0.8)		137±82 smolts 1975-80; 105 fg 1978; USFWS 1981, QFiD 1981c.

a. Mean ± standard deviation (range), thousands of fish. Fg = fingerling; yr, yearling, with planting dates.

b. 81±87(16-221) yr Dungeness coho 1958-69.

c. Also Hoh, Quinault X Green R., and Dungeness R.

d. Quinault, Soleduck, Willapa, Toutle, Green, Quilcene, mostly into Salmon R.

e. Quilcene, Purdy Cr., Moclips, Willapa, Soleduck, Simpson, Skagit, Green R., Hood Canal, Cowlitz.

f. Springs from Dungeness, Cowlitz, Cowlitz X Umpqua; Summers mostly Soleduck.

g. 212±77(148-312) fg Dungeness chinook 1958-63.

h. No separation of hatchery and wild catch, still considered essentially a wild stock.

i. Including "early wild" run derived from hatchery stocks.

j. Queets, Quinault, Green R. X Samish, Deschutes.

k. Quinault, U. of Wa., Hoh, Queets, Willapa, Nemah, Finch Cr. Deschutes, Green R., Samish.

l. Catch dominated by hatchery fish of unknown origin after 1979.

river return and time of spawning are thought to be under strong genetic control (Ricker 1972), extensive early spawning may be disadvantageous. (On the positive side, the presence of early returning hatchery fish means that it's sometimes possible to harvest hatchery and wild stocks separately.) Finally, hatchery stocks may show extensive straying upon return, i.e., dispersal from their release site to spawn elsewhere (QFiD 1981c). Since 1979, for example, summer steelhead catches on the Hoh, Queets and Quinault have been dominated by hatchery fish straying from unknown areas. (These fish could originate from the large hatchery program on the Quillayute River. Also, two tagged fish caught in the Quinault originated from Columbia River hatcheries.) Such straying would, again, seem to have the potential for accelerating gene flow and altering the genetic makeup of the small wild stocks.

Extensive hatchery programs occur on the Quillayute and Quinault Rivers; programs are less extensive, but increasing on the Hoh and Queets rivers (Table 8). Examination of stock origins show: (1) Two of five coho stocks are derived from native wild stocks (Quillayute summer and fall fish) and three are from stock transfers (Hoh, Queets and Quinault -- the latter two were derived from a wide variety of sources). (2) Three of eight chinook stocks were derived primarily from native stocks (Quillayute fall, Hoh spring/summer and fall); five from stock transfers (some quite extensive). (3) Quinault sockeye were derived essentially from native stock. (4) Three of four chum stocks were derived from transfers, one from indigenous and transferred fish (Quinault). (5) One of five steelhead stocks (Quinault) was locally derived, three originated from transfers, and one (Queets) from a combination. The "Chambers Creek" steelhead stock, transferred extensively throughout Washington, has been derived from several different wild stocks (Royal 1972:104). Obviously, the distances from which

stocks were transferred to establish hatchery runs varied considerably. In several cases hatchery stocks were derived primarily from transfers from adjacent drainages or among the four coastal rivers of interest here.

The numbers and ages of hatchery fish released annually are summarized for each stock. Numbers are sometimes enormous; 1,889,000 fall chinook were planted in the Quinault in 1978. If each was 3 inches long and could be queued head to tail, they would extend nearly 90 miles -- a distance equal to the entire length of the river, including the North Fork. But the numbers of returning adults (the sum of catch, and hatchery return) is the appropriate measure of effectiveness. Recent examples include: Quinault hatchery sockeye returned at a rate of .014/smolt released; 3-year-old Quinault winter steelhead, at .0205-.0431, with 4-year-olds at .01-.0186 (QFiD 1981c), 3-year-old Quillayute winter steelhead at .069; 4-year-olds at .017 (WDG 1982); Quillayute summer coho at .0039 (WDF 1982c).

The potential effects of hatchery fish upon wild populations depend in part upon their relative numbers. Some crude measure of these relationships can be made by comparing catches or escapements and hatchery returns in Tables 3 and 8, with the difficulty that the wild fish catch cannot be clearly separated from hatchery fish for a number of important stocks. The following hatchery stocks are thought to have relatively small impacts on their wild counterparts, either because returns are presently small in relation to wild runs and most hatchery fish are returning to a particular downstream hatchery site, or releases have been made for too short a period, or releases appeared to be unsuccessful and were discontinued: Hoh coho, Quillayute fall chinook, Hoh chinook, Queets chinook, Quinault spring/summer chinook, Quinault sockeye, Quillayute, Hoh and

Queets chum. Situations where present hatchery-based stocks are greatly dominant over wild fish (i.e., the run is considered essentially a hatchery stock by some managers) include: Quillayute spring/summer chinook (especially the spring form), Quinault chum, Quillayute summer steelhead, and perhaps the Hoh, Queets and Quinault summer steelhead. The status of wild Ozette sockeye is confused, but a program is underway to augment a greatly diminished wild native stock with Quinault stock (Blum 1982 per. com.).

The remaining nine hatchery stocks occur with substantial numbers of wild fish (but the hatchery and wild stocks may be separated to some extent by time of river entry). Presently the approximate wild:hatchery fish proportions in the commercial catch are: Queets coho .33:.67(1980-82); Quinault coho .31:.69 (1980); Quinault fall chinook .16:.84(1980-81); Hoh winter steelhead .37:.63 (1979-82), Queets winter steelhead .63:.37(1980-82); Quinault winter steelhead .49:.51(197881). The Queets River winter steelhead run apparently had consisted of wild fish up until the 1980-81 winter (QFiD 1981c). Additionally, the proportion of wild to hatchery Quillayute winter steelhead in the combined commercial and sport catch was .14:.86 for 1977-79. The proportion of estimated wild escapement to hatchery returns for summer coho on the Quillayute was .24:.76 for 1979-81. The proportion of wild to hatchery Quillayute fall coho could not be determined. These crude comparisons overestimate the proportion of hatchery fish in a run, especially for steelhead, because commercial fishing may be concentrated on the early part of a run where hatchery fish predominate. All data are from sources listed in Tables 3 and 8.

A comparison of the 19 wild stocks thought to be of initial concern to ONP (p. 27) with the hatchery operations reported above shows that 18 have corresponding hatchery stocks (only the Ozette fall chinook stock is not receiving hatchery fish at present). Seven of these 18 wild stocks are classed currently as having only a comparatively minor hatchery counterpart (Hoh coho, spring/summer chinook on the Hoh, Queets and upper Quinault, fall chinook on the Bogachiel and Queets, Quinault sockeye). Eight of the remaining wild stocks have strong hatchery counterparts [Quillayute summer coho, Queets and Quinault coho, Quinault fall chinook, winter steelhead on Quillayute (i.e., Soleduck and Bogachiel), Hoh, Queets and Quinault]. Finally, the small wild summer steelhead stocks on the Hoh, Queets and Quinault may be dominated by hatchery strays. Clearly, the management of the 11 wild stocks in these latter two categories is of immediate concern to ONP. Hatchery programs on the coastal rivers seem to be in a constant state of flux, but generally are increasing. These comparisons of hatchery to wild stock relationships will be rapidly outdated. Potential conflicts of hatchery based programs with NPS objectives are discussed below (Management).

MANAGEMENT

Management Considerations. Olympic National Park is to be managed as a natural area. Ideally, ecological processes, including the natural regulation of animal numbers, should be permitted to proceed as under "pristine conditions," and modern man should be restricted generally to nonconsumptive uses. As a Biosphere Reserve, Olympic is seen also as a reservoir of genetic diversity (Franklin 1977) and as a potential environmental baseline to which other, exploited, systems may be compared (Jenkins and Bedford 1973, Martinka 1978). These unique management objectives must be modified, obviously, for anadromous fish where the park is not a complete ecological unit, just as they are modified for populations of migratory ungulates or waterfowl. In theory, the problem becomes one of reconciling two different uses of the same resource: the important commercial and recreational harvests -- an intense consumptive use, with the preservation of ecosystem processes. In practice, the noncomsumptive uses for which the park was established have rarely, if ever, been considered seriously in the larger scheme of cropping a resource worth millions of dollars annually and set in a management atmosphere which can be described fairly as a morass of conflicting biological, legal, economic, and social issues (See Ellis 1977, McMinds 1979, Brown 1982, Pacific Fisheries Management Council 1983).

The NPS concern with maintaining or restoring representative natural populations of anadromous salmonids can be separated into three broad but interrelated issues: (1) The numbers of fish, (2) The genetic composition of stocks, and (3) The role of fish as food for carnivores other than man.

(1) The Numbers of Fish. Harvest theory and practice show that cropping a population to produce a sustained yield (SY) reduces and maintains animal

numbers below the equilibrium unharvested level. Salmon harvest theory predicts that yield from future populations is greatest at some intermediate stock size, and that the maximum sustained yield (MSY) is associated with an optimum escapement that may be only 30-50% of the unfished population level (Larkin 1977, 1978). MSY is defined as the largest average catch that can be taken continuously from a stock under existing environmental conditions. Optimum escapement may be defined as that number of spawners which produces the future MSY (Workshop on Spawning Escapement Policies for Coastal Coho 1982). For example, analysis of Quinault sockeye stock-recruitment relationships suggested that optimum escapement is less than 25,000 fish -- higher levels did not, on average, produce greater yields (Gilbertson 1981).

For most major wild stocks of anadromous fish, the primary objective of all harvest management agencies, except NPS, is to identify MSY and maintain populations at optimum escapement levels (exceptions are stocks not fished commercially -- cutthroat trout, Dolly Varden, etc.). The methods used to identify optimum escapement and the relationship of present numbers to optimum levels are both in dispute for the major stocks of concern to ONP (See WDF and Quinault Treaty Area Tribes 1982, QFiD 1982c, Hartt 1982a, HTF 1982b). Two basic methods are being used in attempts to identify optimum escapement: (1) analysis of stock-recruit relationships (these listed in Table 4), and (2) juvenile production models -where stream habitat types are measured, the average production of young by type is calculated, and the number of parent spawners necessary to produce the young is back-calculated from estimates of fecundity and survival. Errors in estimating the escapement and the production of young, the effects of environmental variation, and variable ocean fishing rates interact to confound measurements of optimum escapement (Larkin 1978,

Walters 1981, Ludwig and Walters 1981, Walters and Ludwig 1981). The available data and the methods potentially of use to identify optimum escapements for coastal coho stocks were reviewed in a recent workshop (Workshop on Spawning Escapement Policies for Washington Coastal Coho 1982). Participants concluded that information was presently insufficient to determine optimum levels, but recommended that work continue to obtain data necessary to construct useful stock-recruitment models. Similarly, optimum escapements for chinook stocks are considered to be poorly defined. An experimental "probing" approach to management was recommended to the U.S. District Court overseeing harvest disputes, where escapements are manipulated deliberately and subsequent recruitment is monitored (Hartt 1982a,b). Harvest and escapement data for most steelhead stocks are even more limited than for salmon stocks. Thus, with the possible exception of Quinault sockeye (and even this is in dispute, WDF 1981) the present information does not permit identification of optimum escapements for wild stocks, but, at best, provides a hazy view of the ranges in which optimum levels may occur.

Recent freshwater exploitation rates (river harvest/total river run size) for major wild stocks of concern to ONP are calculated to be: Quinault sockeye, $.40 \pm .15$ (1973-80, data from Gilbertson 1981); Queets winter steelhead, $.49 \pm .20$ (1971-82, QFiD 1982d); Quinault winter steelhead, $.43 \pm .15$; Hoh winter steelhead $.40 \pm .05$(1979-82, HTF 1982a,b); Queets spring/summer chinook, $.21 \pm .03$(1978-81); Hoh spring/summer chinook, $.35 \pm .07$(1978-80); Queets fall chinook, $.30 \pm .13$ (1978-80); Hoh fall chinook, $.36 \pm .17$(1978-80); Quileute fall chinook, $.26 \pm .12$ (1978-80, all from QFiD 1982c); Quinault coho, $.45 \pm .10$(1978-81); Queets coho, .18(1980, QFiD 1982a); Hoh coho, $.33 \pm .02$(1980-81 HTF 1982a). Substantial ocean harvest of coho and chinook occurs in addition to the river harvest rates

calculated here. Apparently, very little is known about ocean harvest rates for wild coastal coho and chinook stocks, although ocean harvests for some chinook stocks may average .66 (WDF as cited by Quinault Tribal Fisheries 1982c). Most estimates of exploitation rates computed here are crude approximations that compound the errors in estimating escapement, sport catch, etc. Calculations indicate the approximate magnitude of harvests, which must be particularly heavy on coho and chinook, but they do not indicate where present escapements lie in relation to optimum levels.

The "pristine conditions" that ONP would preserve ideally in managing anadromous fish would be represented by stocks that were modestly exploited for subsistence (and perhaps trade?) by coastal tribes. Historic accounts indicate that escapements were high following Indian harvests. This ecological state will obviously not recur. Even if all stocks were currently maintained at optimum escapements the number of adult fish returning might be, as a guess, one-half or less of the lightly exploited levels. If current escapements are depressed below optimum, then departures from this idealized pristine state would be even greater. Management programs favoring large hatchery stocks for Quinault fall salmon and winter steelhead runs and for Quillayute summer coho almost assure that corresponding wild stocks will be depressed below optimum levels. From the standpoint of NPS management objectives, "optimum" escapement represents the <u>minimum</u> tolerable levels for wild stocks; populations well above optimum would be preferable. Management for large hatchery stocks clearly poses the greatest conflict with NPS objectives.

There are a number of risks associated with MSY management that need to be evaluated before NPS accepts such objectives. Populations harvested for high

sustained yields may take longer to recover from environmental disturbances (Beddington and May 1977), particularly when there are strong interactions between harvested species (May et al. 1979). Salmonid stocks, as well as many other animal populations, may be viewed as having several equilibrium states (Peterman et al. 1978). MSY exploitation is close to rates that may cause a population to drop into a lower stable state -- where heroic measures may be required to boost it back into higher levels (Peterman 1977, McIntyre 1980). (The Ozette sockeye may be a good example of a population occurring now in a lower state even though harvests have been reduced.)

MSY management might affect the intensity of natural selection. Escapements that produce numbers of juveniles above the short-term optimum levels may increase long-term fitness of the stock because of competition among juveniles (Coastal Coho Workshop, 1982).

(2) <u>Genetic Composition of Stocks</u>. Production of hatchery based stocks increased in coastal rivers as wild fish declined with increased fishing (particularly in the mixed stock fisheries at sea) and with habitat degradation outside the park. The influence of hatchery stocks, particularly those established from stock transfers, on the genetic composition of wild stocks needs evaluation.

There is increasing evidence that some of the morphological, behavioral, and physiological differences among stocks of salmon and steelhead have a genetic basis (as opposed to being environmental) and that some of these differences may be adaptive (i.e., the result of natural selection rather than chance) (Ricker 1972, 1981, McIntyre 1977, 1983, Milner et al. 1981, Larkin 1981, Reisenbichler 1981, 1983, Reisenbichler and McIntyre 1977, Utter and Allendorf

1977, Utter et al. 1980). Much of the evidence for genetic variation in chinook, coho and steelhead has been summarized nicely by the California Gene Resource Program (1982) -- which also emphasizes the practical need of fisheries managers to maintain the genetic diversity of salmonid resources (See also Institute of Fisheries Research Biologists 1975, Helle 1976, 1983, Smith and Chesser 1981).

The extent of genetic diversity among native wild stocks on the geographic scale of the coastal rivers of concern to ONP is not clear. The effects on the diversity of native wild stocks from transfers for hatchery programs and human selection from fishing (Ricker 1981) are similarly unknown. However, the studies of diversity cited above, the environmental differences among coastal rivers, and the limited circumstantial evidence from life history data on coastal stocks, all suggest that genetic differences may occur, and that a conservative view toward the preservation of this possible diversity is appropriate for ONP. Studies in progress should help clarify the nature of existing diversity and suggest ways to minimize conflicts with ongoing hatchery operations (Reisenbichler 1982). It is worth noting that Rich (1920 cited by Ricker 1972) commented that "The chinooks of the Quinault have the largest eggs of any chinooks with which I am acquainted -- approximately 10 mm in diameter as compared with 6 or 7 for most fish of the Columbia. It is significant also that these Quinault chinooks are locally designated as 'black salmon' -- a fact which indicates some racial differences in colouration." It's unclear to me to what extent egg size is either heritable or adaptive -- but it is not too difficult to conjure up the selective forces that might place a premium on large egg size in coastal rivers. From the standpoint of the park's objective of preserving genetic diversity, it makes little

difference if diversity is adaptive or the result of chance variation -- these fish represent evolutionary experiments that should be allowed to proceed within the park with minimal human influence. There are strong practical reasons, in addition to cultural and scientific values, to consider designating the rivers of ONP and the wild salmonids they contain as "gene banks" to conserve genetic diversity of wild stocks (Helle 1976, 1983). Minimizing the influence of introduced hatchery stocks should be part of the broad NPS management goal of maintaining wild stocks at or above optimum escapement levels.

(3) Anadromous salmonids as food for native carnivores. The role of salmonids as food for aquatic and terrestrial carnivores and in the nutrient dynamics of aquatic ecosystems of the park has been discussed briefly by Sedell et al. (1982). Although there are a number of studies which demonstrate that sockeye contribute substantially to phosphorus and nitrate budgets in lake ecosystems (Donaldson 1967, Krokhin 1959, 1975), very few studies are available of salmon carcasses in the nutrient dynamics of streams and rivers. Richey et al. (1975) attributed a marked increase in primary production, periphyton biomass and nutrient concentrations in a small stream to the decomposition of salmon carcasses (landlocked sockeye). Decomposition of pink salmon carcasses increased the nitrogen concentrations of a small stream in Alaska and the adjacent estuary. Carcasses also influenced the nature of the sediments deposited in the estuary (Brickell and Goering 1970). The role of carcasses in the dynamics of stream ecosystems may be more subtle than generally appreciated. Carcasses from anadromous alewives (*Alosa pseudoharengus*) released large supplies of energy stores in the leaf litter of ponds and streams by providing nitrogen and phosphorus that stimulated microbial decomposition of leaves. This effect apparently increased overall food

production far beyond the levels expected from just the biomass of alewives (Durbin et al. 1979).

Surprisingly, a high proportion of the carcasses may remain in the spawning areas, even in large streams subject to high flows. In an imaginative study to determine the fate of chum salmon carcasses on the Skagit River in Washington, radio transmitters were placed in 76 live post-spawner salmon and in 27 carcasses during December 1979-January 1980 (Glock et al. 1980). About 48% of the carcasses drifted less than 6.5 miles, even during a severe flood. Carcasses washed up on gravel bars, became stranded in backwaters or buried in sediments. In a repeat study, 214 live post-spawner chum were tagged and released during December 1980 (Hunt and Johnson 1981). Twenty-nine tags were recovered. Carcasses traveled a mean distance of 4.8 miles. Ten carcasses were eaten by bears and nine by eagles. Our perception of the historic role of salmon carcasses in stream ecosystems may be skewed badly, because the number of carcasses is now lower and because many streams outside the park have been altered (straightened, diked, and the logs, debris and rocks removed) to the point that their effectiveness in "trapping" carcasses may be greatly reduced (a suggestion by E. O. Salo 1982 per. com.). In addition to carcasses, salmon eggs deposited in the gravel could represent important nutrient input, since most do not survive (Cederholm 1983 per. com.).

Juvenile and adult salmonids could contribute substantially to the diets of at least 25 species of fairly common predatory or scavenging birds and mammals in ONP. Mammals range from spotted skunks (Spilogale putoris) to black bears (Ursus americanus); birds, from belted kingfishers (Megaceryle alcyon) to ospreys (Pandion haliaetus) and bald eagles (Haliaeetus leucocephalus).

Virtually nothing is known about population trends or the role of salmonids in the diets of most species in the park. Observations made during redd counts from 1979-82 showed that salmon carcasses were rapidly consumed in the park (Peterson 1983 per. com.).

Salmon formed an appreciable part of the late summer diets of black bears from heavily forested areas of Alaska, particularly when alternate foods, such as berries, were unavailable (Modafferi 1982). Black bears preyed heavily upon live chum and pink salmon and scavenged carcasses in Prince William Sound, Alaska (Frame 1974). Bears preferred female salmon over males and selected eggs over other parts of the carcass. The limited information on black bear food habits in western Washington does not indicate that fish currently make up substantial portions of the diet (Poelker and Hartwell 1973). However, in several of the Washington studies, bears and their scats were collected at sites where they were being controlled to reduce damage to conifer regeneration. Very few samples were collected during the autumn or where bears had access to significant salmon runs (Poelker 1983, per. com.). Chum and coho salmon represented very important winter foods for bald eagles on the Skagit River (Stalmaster 1981, Glock et al. 1980, Hunt and Johnson 1981). The meager evidence available suggests that adult salmon could represent important food supplies for park carnivores. Since most carnivores are opportunistic feeders, and often highly mobile, it's unlikely that any species are dependent upon salmon as food. However, considering the biomass of spawners and carcasses available historically, their reduction must represent a substantial departure from pristine ecological relationships in the park by affecting nutrient cycles and carnivore numbers and distribution. This interpretation is supported by historical accounts. Fisher (Unpubl.) commented on the great abundance of

salmon in the Queets River during September 1890. He observed: "At every few yards was to be seen the remains of a fish where cougar, coon, otter, or eagle had made a meal."

Finally, some fisheries managers tend to regard any spawning salmon and steelhead over and above the numbers necessary for optimum escapement to be "wasted" (i.e., the fish does not pass through the human digestive tract or pocket book). This is an appropriate perspective for hatchery stocks and perhaps for wild stocks outside the park -- but the view of unharvested fish as waste is wholly inappropriate within a national park.

Recommendations for Management and Research. Recommendations for managing specific stocks of wild fish are beyond the scope of this report and the expertise of its author. However, a number of general research questions and management concerns became apparent as the report was prepared. What follows is an annotated list of needs, suggestions, and questions. Since ongoing studies funded by NPS are expected to address the issues of genetic differentiation of stocks, structure of fish communities, and the nature of stock-recruitment relationships (Reisenbichler 1982), these needs are not listed below.

Research.

1. Analyze the frequency and magnitude of peak and low flow characteristics of coastal rivers. If the historic frequency of floods can be assessed and their effects on salmonid survival determined (e.g., density independent or density dependent mortality), this analysis may demonstrate how estimates of optimum escapement should be modified to assure that populations are maintained at the most productive levels in a highly variable environment.

2. Evaluate stock trends by analyzing historic information and estimate pristine population levels from habitat characteristics (See Chapman 1981). This should provide a basis to assess the extent of current departures from natural conditions.

3. The life history, numbers, and distribution (particularly) of certain stocks of concern to ONP are poorly known. These include Quillayute summer coho, spring chinook and summer steelhead. Stock distribution for spring chinook may be determined by using radio transmitters (U.S.F.W.S. - Spring Chinook Salmon Research Proposal 1982). If so, then the movement and consumption of chinook carcasses should also be monitored.

Management (NPS).

1. Reevaluate the nature and extent of fishing in the park to improve the management policy for anadromous fish. The NPS has been criticized for continuing to allow fishing within natural areas (Darling and Eichhorn 1967, Dasmann 1976). If fishing is to continue it must be compatible with other park objectives and values. The policies evolved in Yellowstone Park may serve as a guideline: High quality fishing is permitted by conservative use of native populations when it can occur without endangering fish populations or impairing other scenic, ecological, or scientific values of the park (Yellowstone Park Staff 1979). Catch and release (CR) fishing for some wild stocks may be most appropriate in ONP and should be explored fully. CR fishing could mean that more waters in the park will be open to fishing than at present, but fewer wild fish will be killed. Expanded CR fishing opportunity should not be attempted unless the manpower for effective enforcement is available. The effects of the restricted kill of wild fish on court-ordered harvest allocations between Indian and non-Indian fishermen would need to be examined.

2. Develop or expand programs to monitor escapement of certain stocks important to ONP. Summer coho escapement counts could be intensified, as well as counts of fall salmon and steelhead on the upper Quinault and the upper Quillayute system. The status of anadromous fish stocks in the small streams of the park's coastal strip should be determined.

3. Evaluate the amount and effectiveness of the effort directed at enforcing fishing regulations. ONP issued an average of 7 $\pm$ 3 citations per year for fishing violations on west-side rivers from 1980 to 1982. Enforcement effort is difficult to measure. The best records are for the Queets River, where a

minimum of 189 hours of enforcement effort occurred during fall, winter and spring periods from February 1981 to February 1983 (Smith 1983 per. com.). (Effort during summers could not be identified separately in patrol logs.) Six-hundred anglers were contacted on the Queets from July 1982-February 1983, and 162 fish were examined (MacCartney 1983 per. com.). It may be necessary to redirect enforcement effort to protect certain stocks, particularly when size limits are in effect.

4. Inventory the blockages to spawning fish from road culverts in the park and construct fish passage facilities (baffles, gabions, bridges, etc.). Culverts at East Twin Creek on the Hoh River are known barriers to anadromous fish.

5. Investigate the applicability of legal precedents for defending park fish stocks from adverse actions which occur outside park boundaries.

6. Emphasize anadromous fish in several of the park's interpretive programs. The opportunity for park visitors to view wild summer coho at Salmon Cascades on the Soleduck River should be advertised widely.

Management (Cooperative). The ability of the NPS to maintain a semblance of natural aquatic ecosystems will depend heavily upon the cooperation of state, federal, and tribal agencies.

1. The goals, intensity and effectiveness of hatchery operations on park rivers need reappraisal. The NPS must participate in planning hatchery programs whenever fish releases will influence wild stocks of concern to the park. Alternative management strategies should be explored.

Questions to be addressed could include:

a. Is production of wild fish from the upper Quinault River being fully realized? Part of the rationale for increased hatchery production on the Quinault was that improper logging severely damaged spawning streams on the Quinault Reservation. How quickly do these streams recover? How many have recovered?

b. Must the Quillayute summer coho be managed as a hatchery stock? If so, could the harvest rates on hatchery fish be reduced, thereby reducing harvest of wild fish?

c. Are there techniques of fish culture available that could be used to reduce straying of returning hatchery fish into park rivers?

d. The effectiveness of some hatchery steelhead programs is unclear. Have hatchery programs significantly increased the number of fish caught, or have they simply substituted hatchery fish for wild fish that could be restored? What are the effects on stock distribution of replacing early run wild fish (December-January river entry) with hatchery fish? Apparently, late run wild fish (March-April) tend to spawn in downstream areas. <u>If</u> there was also a tendency for early wild female steelhead to penetrate to headwater areas to spawn, and these have been replaced largely by hatchery fish, then wild steelhead in upstream areas of the park may have been reduced disproportionately.

e. Review hatchery programs more frequently. The NPS should oppose major stock transfers until more is known about the effects on genetic diversity of wild stocks. The proposal by WDF to create hatchery runs of summer coho on the Hoh, Queets and Quinault rivers (WDF 1982e) seems particularly inappropriate unless straying could be prevented into upstream areas in the park.

2. Restore anadromous fish to the upper Elwha River. Elimination of these stocks by dams altered dramatically the fauna of the river that drains the heart of Olympic Park.

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APPENDIX

TABLE I. ANADROMOUS FISH DISTRIBUTION ON SOUTH, EAST, AND NORTH SIDES OF OLYMPIC NATIONAL PARK [a/]

Drainage	Report
W. Fk. Humptulips	Does not enter park.
Wynoochee	Historically blocked by falls.
S. Fork Skokomish	Anadromy to above Church Cr., but still 4-5 miles below boundary.
N. Fork Skokomish	Anadromy blocked by dams. This probably eliminated 2 miles of habitat in ONP which apparently ended at Staircase Rapids historically. (1) Kokanee occur in the lake and spawn in main river to rapids. (2) A landlocked race of chinook salmon occur in the lake and spawn in river, mostly in campground area in October. These are 5 year olds that reach about 20 lbs. (Frank Haw, WA Dept. of Fisheries) 1982 per. com.
Hamma Hamma	Outside park.
Duckabush	Anadromy restricted naturally to lower 7 RM's, about 4.5 miles from below boundary.
Dosewallips	Anadromy blocked naturally below park boundary.
Dungeness - Gray Wolf	Upper Dungeness blocked at RM 18.8. Upper Gray Wolf - fish may ascend to about RM 9, but mostly to RM 8. This means that about 1 mile of river in the park is available for anadromy. This area used by coho, and a unique early run of pink salmon. Spring chinook might get into ONP. (Tim Flint, WA Dept. of Fisheries per. com.)
Morse Cr.	Blocked at RM 3.8
Elwha	Blocked by dam at RM 4.9. A major loss of anadromous fish to the park.

a. All information from WA Dept. of Fisheries personnel and WA Dept. of Fisheries stream catalogues (1975) for Puget Sound and Coastal waters.

TABLE II. THE APPROXIMATE DISTRIBUTION OF COHO SALMON SPAWNING AND JUVENILE REARING WITHIN AND ADJACENT TO OLYMPIC NATIONAL PARK

DRAINAGE	RIVER MILES UTILIZED FOR SPAWNING & JUVENILE REARING OUTSIDE PARK	INSIDE PARK	(%)	TOTAL	COMMENTS AND SOURCE
FALL COHO					
Petroleum Cr.	5	*	(0)	5	WDF 1975, Blum 1982 per. com.
Ozette R. (Mainstem)	*	4	(100)	4	Blum 1982 per. com.
" L. (Tribs.)	47	3	(6)	50	
Cedar Cr.	2	1	(67)	3	
Ellen Cr.	1	3	(75)	4	
Quillayute					QTF 1982.
Dickey (Tribs.)	54	-	(0)	54	
Soleduck (Tribs.)	50	-	(0)	50	
" (Mainstem)	(49)	-	(0)	(49)[a]	
Bogachiel (Tribs.)	25	4	(14)	29	
" (Mainstem)	(22)	(8)	(27)	(30)	
Calawah (Tribs.)	20	1	(5)	21	
" (Mainstem)	(32)	(1)	(3)	(33)[a]	
Scott - Mosquito Cr.	2	7	(78)	9	
Hoh (Tribs. incl. S. Fork)	33	21	(39)	54	Jorgensen 1982 per. com., and WDF undated map.
Hoh (Mainstem S. Fork)	(30)	(28)	(48)	(58)[a]	" " " " " " " "
Cedar Cr. - Kalaloch CRS	17	3	(15)	20	WDF 1982 pers. com.
Queets (Tribs.)	19	26	(58)	45	Lestelle 1982 per. com.
" (Mainstem	(4)	(37)	(90)	(41)[a]	
Clearwater (Tribs.)	57	-	(0)	57	
" (Mainstem)	(35)	-	(0)	(35)[a]	
Salmon (Mainstem)	(11)	(1)	(8)	(12)[a]	
" (Tribs.)	4	-	(0)	4	
Quinault, Lower (Tribs.)	45	-	(0)	45	Lestelle 1982 per. com.
" " (Mainstem)	(29)	-		(29)[a]	
" Upper (Tribs. incl. Lake	7	20	(74)	27	
" " (Mainstem[b])	-	(24)	(100)	(24)[a]	10 miles common boundary.
SUMMER COHO					
Quillayute					
Soleduck (Mainstem)	*	13	(100)	13	5 miles common boundary. Chitwood 1982 per. com.
" (Tribs.)		2	(100)	2	

a. Mainstem includes terrace tributaries and spring creeks used for spawning and rearing, plus side channels and other sites used as rearing areas (Sedell 1982, WDF 1982b.)

b. Includes North Fork.

* Less than 1 mile.

TABLE III. THE APPROXIMATE DISTRIBUTION OF CHINOOK SALMON SPAWNING WITHIN AND ADJACENT TO OLYMPIC NATIONAL PARK

DRAINAGE	RIVER MILES UTILIZED FOR SPAWNING OUTSIDE PARK	INSIDE PARK	(%)	TOTAL	COMMENTS AND SOURCE
SPRING/SUMMER CHINOOK					
Quillayute	4	*	(0)	4	Chitwood 1982, per. com.
Soleduck (Mainstem)	52	10	(16)	62	
" (Tribs.)	6	-	(0)	6	
Bogachiel (Mainstem)	22	10	(31)	32	
Calawah (Mainstem)	11	-	(0)	11	
" (S. FK. & Tribs.)	7	*	(0)	7	
Hoh (Mainstem)	14	18	(56)	32	Spring run uses RM 35-47.5, all in Park. Jorgensen 1982 per. com.
" (Tribs.)	4	1	(20)	5	
" (S. Fk.)	4	7	(64)	11	Spring run uses 9.5 M with 6.5 M in Park.
Queets (Mainstem)	2	33	(94)	35	Lestelle 1982 per. com.
" (Tribs.)	2	6	(75)	8	
Clearwater R.	25	-	(0)	25	
Quinault (Mainstem)	6	17	(74)	23	Lestelle 1982 per. com.
" (Tribs.)	-	13	(100)	13	Includes N. Fork.
FALL CHINOOK					
Ozette River	1	3	(75)	4	Blum 1982 per. com., Peterson 1982 per. com.
Quillayute	1	3	(75)	4	Chitwood 1982 per. com.
Dickey (E. Fk.)	8			8	
Soleduck (Mainstem)	52	2	(4)	54	
" (Major Tribs.)	13	-		13	
Bogachiel (Mainstem)	22	10	(31)	32	
" (Major Tribs.)	5	-	(0)	5	
Calawah (Mainstem)	10	-	(0)	10	
Calawah (N. Fk. & Tribs.)	13	-	(0)	13	
" (S. Fk. & Tribs.)	9	2	(18)	11	
Goodman Cr.	*	2	(100)	2	Peterson 1982 per. com.
Hoh (Mainstem)	29	3	(9)	32	Jorgensen 1982 per. com.
" (Main tribs.)	15	-	(0)	15	
" (S. Fk.)	3	*	(*)	3	
Queets (Mainstem)	5	26	(84)	31	Lestelle 1982 per. com.
" (Tribs.)	4	6	(60)	10	
Clearwater	33	-	(0)	33	
Quinault (Mainstem)	29	11	(28)	40	Lestelle 1982 per. com.
" (Tribs.)	3	2	(40)	5	

* = Less than 1 mile.

TABLE IV. THE APPROXIMATE DISTRIBUTION OF SOCKEYE, CHUM AND PINK SALMON SPAWNING WITHIN AND ADJACENT TO OLYMPIC NATIONAL PARK

	RIVER MILES UTILIZED FOR SPAWNING				
DRAINAGE	OUTSIDE PARK	INSIDE PARK	(%)	TOTAL	COMMENTS AND SOURCE
SOCKEYE					
Ozette (Mainstem ?)					Remnant river spawners below lake. Blum 1982 per. com.
" (Lakeshore)	2	-		2	
Quillayute					
Dickey	Dickey Lake				Small stock. Chitwood, Peterson 1982 per. com.
Soleduck and Calawah	Lake Pleasant				Also, some river spawning sockeye. Small stock. Chitwood, Peterson 1982 per. com.
Hoh					River spawning observed in spring creeks in the Park. Jorgensen 1982 per. com.
Queets					Small stock river spawning sockeye (not clear if this is a stock with well defined river spawning life cycle or "strays" from Quinault). Lestelle 1982 per. com.
Quinault (Mainstem)	-	3	(100)	3	(Variable mainstem use.) Gilbertson 1982 per. com.
" (Tributaries)	4	4	(50)	8	
" (Lakeshore)	*	-	(0)	*	
CHUM					
Quillayute					
Dickey	3	*	(0)	3	Chitwood, Peterson 1982 per. com.
Soleduck	3	-	(0)	3	
Hoh					Sporadically to Owl Cr. in mainstem. NPS jurisdiction limited to coastal strip. Jorgensen 1982 per. com.
Queets					Sporadically below Sam's River. Lestelle 1982 per. com.
Quinault					Sporadically in mainstem and lower reaches of all tributaries to a point 4 miles above Lake Quinault - but may be largely from hatchery strays. Gilbertson 1982 per. com.
PINK					
Quillayute	Rare				
Hoh	Rare				A few observed every year.
Queets (Mainstem & Clearwater)	7	3	(30)	10	Lestelle 1982 per. com.
Quinault (Mainstem)	11	-	(0)	11	

* = Less than 1 mile.

TABLE V. THE APPROXIMATE DISTRIBUTION OF STEELHEAD SPAWNING WITHIN AND ADJACENT TO OLYMPIC NATIONAL PARK [a]

	RIVER MILES UTILIZED FOR SPAWNING				
DRAINAGE	OUTSIDE PARK	INSIDE PARK	(%)	TOTAL	COMMENTS AND SOURCE
Ozette Area				?	Stock distribution poorly known. Blum 1982 per. com.
Big River	6?	-		6?	
Cedar Cr.	1	2	(67)	3	
Quillavute	4	*	(0)	4	Chitwood 1982 per. com.
Dickey	27	-	(0)	27	
Soleduck (Mainstem)	52	14	(21)	66	
" (Major tribs.)	16	2	(11)	18	
Bogachiel (Mainstem)	22	10	(31)	32	
" (Major tribs.)	5	-	(0)	5	
Calawah (Mainstem)	39	4	(9)	43	
" (Major tribs.)	10	1	(9)	11	
Goodman Cr. - Mosquito Cr.	3	4	(57)	7	
Hoh (Mainstem, incl. S. Fk.)	33	28	(46)	61	Jorgensen 1982 per. com.
" (Major tribs.)	16	3	(19)	19	
Kalaloch Cr.				?	
Queets (Mainstem)	3	37	(93)	40	Lestelle 1982 per. com.
" (Major tribs.)	31	17	(35)	48	
Clearwater	67	-	(0)	67	
Salmon	16	1	(6)	17	
Quinault (Lower mainstem)	29	-	(0)	29	Lestelle 1982 per. com.
" (Lower tribs.)	40	-	(0)	40	
" (Upper mainstem)	-	23 [b]	(100)	23	
" (Upper tribs. incl. lake	7	15	(68)	22	Includes N. Fork.

a. Winter and summer stocks not distinguished. b. 11 miles common boundary. * = Less than 1 mile.